"Let Knowledge grow from more to more."—TENNYSON.

KNOWLEDGE

AN ILLUSTRATED MAGAZINE OF SCIENCE

SIMPLY WORDED—EXACTLY DESCRIBED

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Edited by A. COWPER RANYARD.

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INDEX.

INDEX OF ILLUSTRATIONS.

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LONDON: MARCH 2, 1891.

CONTENTS.

ON THE FORM OF THE MILKY WAY.

By John Richard Sutton, B.A.Cantab.

The late Mr. Proctor shone as a critic. One gets the same impression from a literary review by him as from one of Matthew Arnold's literary reviews, viz. that in most cases common sense has little more to say. His essays on the star-work of the two Herschels are among the most masterly in the language, and are destined, no doubt, to be read for generations. But his original speculations are not always so happy. His genius was iconoclastic rather than creative; and although few who have appreciated the significance of the work of Michell and the school he set up will question the fact that Proctor has successfully summed up, once for all, the case against Sir William Herschel's "cloven-flat-disc theory" of the Milky Way, yet it is doubtful if the same success can be claimed for the "spiral theory," which he advanced as comprehending all the results of observation on the stars and nebulæ.

It would be out of place here to enter into a discussion of the stellar researches of the Herschels. It will be sufficient to say that the elder Herschel assumed the stars to be, *on the average*, scattered more or less uniformly throughout the visible universe, and hence, by counting the number of stars visible in any one direction, he was, as he thought, able to arrive at a pretty fair approximation to the depth of the star-system in that direction. [It is not hard to see that when the telescope is fixed on any point in the sky, the boundaries of vision trace out a cone in the celestial sphere of which the eye is the vertex.] The younger Herschel seems to have accepted his father's results with little more than a twinge of doubt, although it is not so certain that he placed a very great faith in the trustworthiness of the star-gauging methods from which they were derived; for he could also see, brilliant mathematician as he was, that Michell's application of the doctrines of probability had practically set at rest the fact that *in general* star-grouping was physical and real, and not merely optical, and hence that the stars were by no means uniformly distributed. Still, the doctrine of probabilities had not sufficient hold upon his mind to cause him to give up the delightfully systematic results of star-gauging, to say nothing of the paternal authority by which the old theory was backed.

Proctor, however, took higher ground. In his hands Michell's researches were, so to speak, born again. The star-groups were physical facts (which, indeed, Sir William Herschel had never doubted, though he left it out of account); the constellations were realities of association (of which Sir William Herschel had never even dreamed); immense streams of stars, physically connected *inter se*, were to be traced across the sky; and, last of all, the Milky Way itself was a great stream of stars*—and not a solid disc—to which all the other streams and groups were subordinate. These different conclusions were advanced from time to time for many years, and, taken together, they comprise an analysis of stellar phenomena whose immense value cannot be denied.

It would be an agreeable task for me to give here, as far as possible, an account of Proctor's very successful work among the stars. But such a course is just now out of the question; moreover, most readers whom this paper may concern will have read his original papers. I shall content myself by remarking that he very early concluded that all available evidence pointed in one direction, namely, that the characteristic feature of our universe, the Milky Way, was one long stream of stars of a spiral form, whose plane passed very nearly through the sun's place. He says: "It is very clear what views we are to form respecting the Milky Way. If the galaxy is, *first*, a clustering aggregation separated from us by an interval comparatively clear of small stars; *secondly*, so shaped that the cross-section of the stream is everywhere not far from a roughly circular figure; and, *thirdly*, associated

* Sir William Herschel's language, even in his early papers of 1784 and 1785, and much more in his later papers on the Construction of Heavens, published in the *Phil. Trans.* of 1802 and 1811, clearly prove that he fully appreciated the fact that there are actual clusters and streams of stars, as well as vacant spaces, in the heavens. It is evident, also, that he recognized the connection between the distribution of stars and the distribution of nebulæ. As early as 1802 Sir W. Herschel's language clearly shows that he considered the Milky Way to be a roughly circular ring-shaped region, in which the stars are more thickly grouped than in the space immediately around the sun. He says, in a paper published in the *Phil. Trans.* in 1802: "The stars we consider as insulated are also surrounded by a magnificent collection of innumerable stars, called the Milky Way, which must occasion a very powerful balance of opposite attractions to hold the intermediate stars in a state of rest. For though our sun, and all the stars we see, may truly be said to be in the plane of the Milky Way, yet I am convinced, by a long inspection and continued examination of it, that the Milky Way itself consists of stars very differently scattered from those which are immediately about us." Sir John Herschel also clearly recognized the close clustering of stars in the region of the Milky Way. Mr. Proctor was well aware that both the Herschels had recognized the existence of star-streams as well as groups of nebulæ. But I agree with Mr. Sutton that neither Sir William nor Sir John Herschel proceeded to the conclusion which should have logically followed, namely, that their method of star-gauging could not be relied upon for determining the form of the stellar universe.—A. C. Ranyard.

very closely with the bright stars seen in the same field of view, then must its structure be somewhat as shown in the figure. . . . It will be seen at once how, to an observer placed at S, the various features of the Milky Way can be accounted for by this figure. Towards 1 would lie the gap in Argo; towards 3, 4, 5, two branches, one faint, and in part evanescent through vastness of distance, the other forming the brightest part of the spiral; towards 6 the projection in Cepheus; towards 7 the faint part of the Milky Way in Gemini and Monoceros. The Coal-sacks would be simply accounted for by conceiving that branches seen towards the same general direction, but at different distances, do not lie in the same general plane, and so may appear to interlace upon the heavens. We are not only justified in supposing this, but forced to do so by the way in which the stream of milky light is observed to *meander* on its course athwart the heavens. The branching extensions serve very well to account for the appearance of the Milky Way between Cepheus and Ophiuchus, where the interlacing branches and the strange convolutions and clustering aggregations described by Sir John Herschel are chiefly gathered."—*Other Worlds*, p. 250.

Proctor's affection for this spiral is remarkable. It was advanced first of all with some caution as a conformation which seemed to account for *all* the known peculiarities of structure in the galaxy—in short, it supplied a useful working theory. For example, he makes the following admission: "I would not have it understood, however, that I at all insist on the general shape of the spiral shown in the figure. On the contrary, that curve is only one out of several which might fairly account for the observed appearance of the Milky Way; and I have often felt inclined to doubt whether a single spiral of this sort is in reality the best way of accounting for the observed appearance of the galactic zone. What I do insist upon as obviously forced upon us by the evidence is that (1) the apparent streams formed by the Milky Way upon the heavens indicate the existence of real streams in space; and (2) that the lucid stars seen on the stream are really associated with the telescopic stars which form, so to speak, the body of the stream. Whether that stream form a single spiral or several, or whether, instead of spirals, there may not be a number of streams of small stars, placed at different distances from us, and lying in all directions round the medial plane of the galaxy, but more or less tilted to that plane (the sun not lying within any one of the streams), are questions which can only be resolved by the systematic scrutiny of this wonderful zone."

But just as Sir William Herschel's working-theories of star-distribution came eventually to be regarded as established facts, so in course of time, without any more apparent grounds, Proctor came to regard his theory with increasing confidence. Scattered throughout his writings will be found very trustful remarks on the conformation of "that strange spiral."

Without doubt, if the star-groups, such as the Pleiades, are real, and not merely caused by stars far apart, though near the same visual-line, being seen projected into a small area of the celestial sphere (and Michell's, not to mention later results, seem to make it certain enough); if the star-streams are real, and not mere optical coincidences; if the manifold signs of association and dissociation among the stars are what common-sense would teach; then it is as certain as the doctrine of chances can make it that the Milky Way is a stream, or collection of streams, of stars. So much, but no more, Proctor has proved. What he has not proved, nor even made possible, is that the Milky Way partakes in any way of a spiral form.

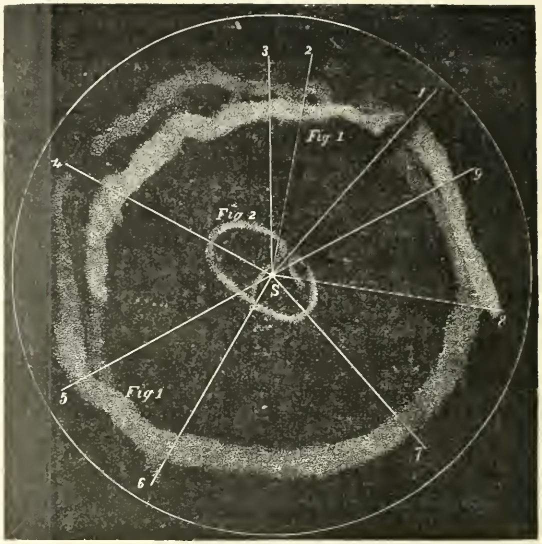


Fig. 1.—The Milky Way as seen in the Heavens.
Fig. 2.—The Spiral Stream which Mr. Proctor assumed represented the actual form of the Milky Way.

Let us see what the brightness of the Milky Way can tell us. Proctor assumed the brightness of its various parts would be a good rough test of their relative distances—a curious mistake for one so conversant with the laws of brightness. [It may be noted that Sir John Herschel erred in the same direction.] Now it may be proved that brightness alone is no test of distance. For let a be the apparent area of any small portion of the Milky Way at some distance taken as unity, and containing n stars, λ the average amount of light received from each star, β the average brightness of the area. If this area be removed to distance d, the light received from each star will be reduced to $\frac{\lambda}{d^2}$; but the apparent area containing the n stars will be reduced to $\frac{a}{d^2}$, and hence the stars are apparently compressed into a smaller area in the same proportion as their light is reduced. β, therefore, remains unaltered. The apparent breadth of the galaxy would be a much safer test of its distance than the brightness, although its actual breadth may vary between very wide limits. As a matter of fact, the broadest parts of the Milky Way are, on the whole, the faintest; whereas in its narrowest part, at the "isthmus" leading into the Southern Cross, it is almost at its maximum brilliancy.

During the course of his long review of the elder Herschel's cloven-flat-disc theory, Proctor pointed out again and again the remarkable tendency of the brighter stars to congregate along the course of the Milky Way and its branches. This feature is so noticeable in the

southern hemisphere that on a bright moonlight night, when the fainter lucid stars are invisible, the position of the Milky Way can be traced by the condensation of the brighter stars alone along its course. Now, there is no antecedent reason why the naked-eye stars should collect upon one part of the Milky Way and not upon another; and hence there is no reason why the fainter parts of the galaxy—assuming them for the moment to be the most distant—should not have collected fourth and fifth magnitude stars in the same way as the brighter and (therefore assumed) nearer parts have collected the brighter magnitudes. But we should not expect to find many of the brightest stars on the fainter and more distant parts. Yet it is a fact that there are stars on the (assumed) more distant streams, and obviously associated with them, as bright as those on the (assumed) nearer ones. Moreover, between the two streams, where the Milky Way is double, and in the Coal-sacks, scarcely a single lucid star is to be seen. This is a singular circumstance. If the spiral theory, or any modification of it as suggested by Proctor, were true, we should expect more, or at least as many, bright stars between the two branches where the Milky Way is double, and in the Coal-sacks, as upon the borders of the Milky Way in any other place. On the other hand, if we regard the two branches as lying at very nearly the same distance from the Sun, we can see at once that the cause which separated them, or keeps them apart—whatever the agency may be scarcely matters in this inquiry—would also *drain*, as it were, the lucid stars from the space between. Add to this the circumstance that the meanderings of one branch correspond to those of the other, and that in one place one branch is made up of alternating bright and faint patches corresponding to faint and bright patches respectively on the other, then we have strong presumptive evidence that the two branches are closer together than any spiral conformation would admit.

All this leads us to conclude that the Milky Way is much as it seems to be at first, namely, a very complex stream of stars roughly hoop-like, and not spiral-like, in form. A piece of old rope thrown into a circular shape represents the Milky Way very well. The frayed ends not quite meeting represent the fan-shaped expansions of the stream on each side of the rift in Argo (a spiral theory does not explain why these expansions should occur just here). A strand untwisted of nearly half the length of the rope, and divided in the middle, would represent the divided branch running from Cygnus through Ophiuchus and Scorpio. Smaller departures would represent the lateral extensions in Cepheus and Perseus. These may be of any size; and it scarcely needs Proctor's assumption that a vast void separates the galactic stars from the faint streams discovered by Sir John Herschel to account for them. This faintness is very likely caused either by sparcity of distribution or by the smallness of the stars (as we have seen brightness is no test of distance so long as light is not lost in its passage through space); indeed, it is pretty clear that the Milky Way is made up of stars of all orders of size and brightness. Local unravellings in the rope would correspond to the Coal-sacks in Crux and Cygnus, and to the lacunæ in Scorpio and elsewhere.

In conclusion, let me add that the aspect of the Milky Way in Argo gives a very strong impression that the stream has been forcibly torn asunder at this place, an impression which is to some extent corroborated by the positions of the bright stars round about, and by the manifold signs of decomposition exhibited by the galaxy in Scorpio and the adjacent constellations.

GIANT BIRDS.

By R. Lydekker, B.A.Cantab.

The only birds existing at the present day which in any sense merit the epithet "gigantic" are the Ostriches of Africa and Arabia, the Rheas of South America, the Cassowaries of Papua and North Australia, and the Australian Emus; and even the largest of these—the male Ostrich—seldom exceeds seven feet in height. The researches of palæontologists have, however, revealed to us that these four groups are but the solitary survivors of a considerably more extensive assemblage of Giant Birds which was once spread over a large portion of the globe, and some of whose members as much surpassed the Ostrich in size as the latter exceeds the Rheas in this respect. Indeed, with our present knowledge of the meaning of the geographical distribution of animals, the very circumstance that the existing Giant Birds are all more or less closely allied, and are found scattered over the globe in areas widely separated and totally disconnected from one another, would of itself have been amply sufficient to indicate that they are the remnants of a group which was at one time of much larger extent, and inhabited regions where such creatures are now unknown. It is unfortunately the case that there are still many gaps in the chain which should link all the existing Giant Birds together, but we may confidently hope that the progress of geological research will little by little reduce the number and length of these gaps.

All the Giant Birds, it may be observed, both living and extinct, are linked together by their incapacity of flight, and the consequent absence of that strong bony ridge or keel which we may observe on the breast-bone of a duck or a fowl, and the presence of which is essential to form a firm support for the powerful muscles required to move the wings. Whether, however, this incapacity for flight is a feature which was always possessed by the Giant Birds, or whether it has been gradually acquired by disuse, is a question which has seriously exercised the minds of those best fitted to decide it, and, since it is still unanswered, may be put aside on this occasion. Moreover, in saying that the Giant Birds are all incapable of flight, it must by no means be inferred that all birds in that condition have any affinity to this group. On the contrary, precisely the opposite is the case, since in the extinct Dodo of the Mauritius we have an instance of a huge pigeon which had evidently lost the power of flight; and the superficial deposits of New Zealand have yielded the remains of a large rail and a goose which were in the same predicament. These and other flightless birds differ, however, essentially in several parts of their organization from the true Giant Birds, and thus have no sort of connection with the subject of this article. There are, however, certain birds, namely the little Kiwis of New Zealand, which, although by no means entitled to rank as Giant Birds in the proper sense of that term, yet as being closely related to the typical members of that group, must find a place therein. Before, however, we can consider the fossil members of this group it is necessary that we should have some idea of the general structure of the leg of a bird, since it is this part of the skeleton which is most commonly met with in a fossil condition, and which affords the most important clue as to the size and affinities of the bird to which it belonged. Some observations on this point have already been made in the article on Giant Reptiles; but since those observations were mainly directed to showing the resemblance between

the leg of a bird and that of a reptile, they are not well suited to our present purpose.

A bird's leg, then, as shown in Fig. 1, is composed of four segments: the upper short one corresponding to the human thigh-bone, and the lowest representing the toes, which are composed of several small bones. Between these two segments are the two long and slender bones shown in the figure. The upper and longer of these two corresponds with the human leg-bone, *plus* the knuckle-bone welded on to its lower end. The lower and shorter bone, of which another example is shown in Fig. 2, is a very remarkable bone indeed, and may be conveniently called the cannon-bone. It is really composed of three separate long bones, of which the ends remain free at the lower extremity and carry the toes, and also of the lower part of the ankle welded on to the upper end. The middle long bone corresponds exactly with the cannon-bone of a horse, the nature of which has been explained in the article on "Rudimental Organs"; and the whole compound bone would correspond with the metatarsus of the extinct three-toed horse known as the Hipparion, if its three metatarsals were welded together, and these again with the bones of the lower half of the ankle. It will, accordingly, be evident that a bird is an odd-toed animal like a horse (that is to say, the toe representing the middle one of the typical five is symmetrical in itself and larger than either of the others), having a cannon-bone, but no separate ankle-bones; the upper ankle-bone having become welded on to the leg-bone, and the lower ones similarly united to the cannon-bone. In these respects, therefore, a bird is a very specialised kind of creature, as departing widely from the original type. With these necessary anatomical explanations, we shall be in a position to enter on the subject of the extinct Giant Birds.

Fig. 1.—The Bones of the Right Leg of the Giant Moa. About $\frac{1}{13}$ nat. size. (*After Owen.*)

Fig. 2.—Front and Back Views of the Left Cannon-bone of a Partridge.

The first of these extinct birds brought to the notice of the scientific world were the Moas of New Zealand, in which islands the largest existing representatives of the group are the diminutive Kiwis. The original determination of the former existence of these giant birds affords, indeed, an interesting instance of the certainty of anatomical deductions, when made with proper care and sufficient knowledge. Thus, many years ago a man brought to Sir R. Owen the broken shaft of the thigh-bone of some large animal, which he stated had been obtained from New Zealand, where the natives believed that similar bones were those of a large eagle. The specimen was a somewhat unpromising one, but after careful comparison the Professor confidently pronounced that it belonged to an extinct bird considerably larger than any ostrich, for which he proposed the name of *Dinornis*. Other specimens soon after brought to this country triumphantly established the correctness of this bold identification, and showed that giant birds far surpassing in size any previously known must have existed at a comparatively recent date, and in extraordinary numbers in New Zealand. In the swamps—especially the well-known one of Glenmark, near Canterbury—these bones, and in some cases nearly entire skeletons, are very abundant; while in caves there have been obtained not only parts of skeletons with the skin still adhering to them, but even well-preserved feathers, and broken egg-shells. Although the Maoris well know that these remains belonged to gigantic birds, and give them a name of which the word Moa is generally considered to be a corruption, yet there is some difference of opinion as to whether their ancestors ever saw these birds in the flesh; some authorities considering that they were killed off by the race which is believed to have inhabited New Zealand before the advent of the Maoris. Still, in any case, Moas must have existed up to a very late epoch; and it is even said that the "runs" made by them were visible on the sides of the hills up to a few years ago, and may, indeed, still be so.

The leg-bone of a Moa may be at once known from that of all living Giant Birds by the circumstance that on the front surface of its lower end, immediately above the knuckle-bone, there is a narrow bar of bone forming a bridge over a small groove (this being indistinctly shown in Fig. 1). In the Giant Moa, of which the leg is represented in Fig. 1, the leg-bone attains the enormous length of one yard, and in an allied species from the South Island its length is upwards of 39 inches. The cannon-bone (as may be seen in the figure) is comparatively long and slender, and is more than half the length of the leg-bone. A skeleton of a smaller individual in the Natural History Museum has an approximate height of $10\frac{1}{2}$ feet, and we may thus conclude that the larger birds did not stand less than 12 feet. There were other species of true Moas, of about the dimensions of a large male ostrich, although of stouter build; and resembling the larger birds in having only three toes to the feet, and not the slightest trace of a wing.

Alongside of these giants there were, however, other species of much smaller size, in which there were four toes to each foot, and the cannon-bone was relatively much shorter. Thus the Dwarf Moa, of which the Natural History Museum possesses a complete skeleton, was not more than three feet high, while Owen's Moa was of still smaller dimensions. There were also other species of this group nearly as large as an ostrich.

Perhaps, however, the most remarkable of all these birds is the Elephant-footed Moa, which, although by no means equal in height to the Giant Moa, was of much more massive build. In this extraordinary bird the leg-bone is much shorter and thicker than in the Giant Moa, while the cannon-bone is so short and thick that it almost loses the character of a "long bone." In one unusually large example of the last-named bone, while the length is only $9\frac{1}{2}$ inches, the width at the lower end is upwards of $6\frac{1}{2}$. By the side of such a bone the cannon-bone of an ox looks small and slender, and the effects of a kick from such a leg can be better imagined than described.

The total number of kinds of Moa inhabiting New Zealand was probably at least fifteen, and, from the enormous accumulations of their bones found in some districts, we may assume that these creatures were extremely common, and probably went about in droves. Nothing like this bird-fauna is known in any other part of the world; and its exuberance may be probably explained by the absence of mammals from New Zealand, so that when the ancestors of the Moas once reached these islands they found a free field for unlimited development.

The nearest allies of the Moas are the small Kiwis; but whereas the latter have long pointed bills for probing in soft mud after worms, the bills of the Moa were short and broad like those of the Ostrich. Moreover, although the Kiwis have no wings visible externally, they retain rudimentary wing-bones, which have totally disappeared in the Moas. The plumage of the Moas appears to have been of the hair-like nature of that of the Kiwis. Since the latter differ from the Ostriches in that the females are larger than the males, we may assume that the same condition obtained among the Moas. The Kiwis are further remarkable for the enormous proportionate size of their eggs; and if anything like the same relative proportions held good with those of the Moas, the egg of the Giant Moa must have been of stupendous dimensions. It is, however, probable that the eggs of the larger Moas were relatively smaller than those of the Kiwis.

Passing to Australia, we find in the superficial deposits remains of a bird as large as some of the medium-sized species of Moa, but at once distinguished by the absence of a bridge of bone at the lower end of the leg-bone. This bird, which has been named *Dromornis*, is, however, as yet but very imperfectly known, so that we are to a great extent in the dark as to its affinities, though it was probably a distant giant relation of the Cassowaries.

Before we again meet with fossil giant birds we have to cross the whole extent of the Indian Ocean to Madagascar. Here there occurs the enormous bird known as the *Æpyornis*, the existence of which was first revealed by its eggs, which are found sunk in the swamps, but of which bones—mostly imperfect—were subsequently discovered. One of these enormous eggs measures three feet in its longer circumference, and $2\frac{1}{2}$ feet in girth; its cubic contents being estimated at rather more than two gallons. The leg-bone of this bird has no bony bridge at its lower end, and the cannon-bone (of which only a portion is known) is as wide as that of the Elephant-footed Moa, but is much longer and thinner. The natives search after the eggs of this bird by probing for them in the soft mud of the swamps with long iron rods.

The Moas, the Dromornis, and the Æpyornis indicate, then, three totally distinct groups of Giant Birds; and since their various habitats occupy islands on both sides of the Indian Ocean, it is a fair presumption that their common ancestors originally inhabited some part of the great continental mass of the Old World. Support is afforded to this hypothesis by the occurrence of the Ostriches on the west, and the Cassowaries and Emus on the eastern side of the same great ocean. Moreover, there is historic evidence to the effect that Ostriches, which are now confined to Africa and Arabia, formerly existed in Baluchistan and Central Asia; and since their fossil remains occur in the Pliocene deposits of Northern India, there is little doubt that at least this group of Giant Birds originated in the northern part of the Old World. Again, the Indian deposits already mentioned have also yielded remains of a bird differing from the Ostrich in having three in place of two toes, and thereby agreeing with the Cassowaries and Emus, to which it was doubtless allied, and thus indicating that these birds likewise had their original home on the great Euro-Asiatic continent, from whence they have gradually migrated southwards till they reached regions free from the large carnivorous mammals of the continents.

Looking back through the Tertiary rocks of Europe to see if we can find there traces of ancestral Giant Birds, it is not till we come to the Lowest Eocene, or period immediately below the London clay, that our search is rewarded. Here, however, both in England, France, and Belgium, we meet with limb-bones and other remains of Giant Birds, which, from their huge size, must almost certainly have belonged to the group under consideration. In this bird, which is known as *Gastornis*, the lower end of the leg-bone has a bony bridge, as in the Moas; and since this is a feature common to the great majority of flying birds, it suggests a community of origin between them and the Giant Birds; the loss of this bridge in the living members of the latter thus being an acquired character. Although we are still very much in the dark as to the real affinities of the *Gastornis*, yet it appears to be more nearly related to the Moas and the Dromornis than to any other birds, and it might, therefore, have well been one of the ancestors of the group.

This is at present the extent of our knowledge of the former distribution of Giant Birds; but it may be confidently expected that whenever the Tertiary formations of Northern Africa and Southern and Central Asia are fully explored, we shall be rewarded by the discovery of other kinds, which will tend to more or less completely connect together those at present known to us, and which will also show how these have gradually migrated, since the Eocene Period, from the great continental northern mass to those southerly areas wherein some have existed up to a comparatively late period, and where others still remain as the sole living witnesses in the Old World of a group which has all but passed away.

THE MAGIC SQUARE OF FOUR.

By T. Squire Barrett, F.S.S.

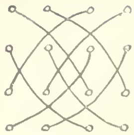
To treat fully of the square of 4 alone would take a good-sized volume. The ancient Egyptians and Pythagoreans, in their ignorance of mathematics, thought it so wonderful that a series of numbers could be arranged to add up alike, upward, across, or diagonally, that they regarded such combinations with superstitious veneration. We, however, know that it would be much more wonderful if magic squares could *not* be made. For example, considering the difficulty with which a person, without some knowledge of the subject, could make a magic square with an arithmetical series of sixteen numbers, it would naturally be thought that it could be done in very few ways. But it was shown by Frenicle that it could be accomplished in at least 880 ways. Nor is this surprising when we consider that there are nearly three billion (2,615,348,736,000) ways of arranging 16 things in the form of a square.

It is more than possible that Frenicle's list does not exhaust the number of such squares. I have never seen his collection, and was therefore rather surprised to find that I could make exactly the same number, but no more. Nevertheless, I should not like to say that others could not be constructed.

These 880 squares, consisting as they do of numbers in arithmetical progression, may obviously be classified according to the relative position of each pair of complementary numbers. When the numbers are the natural series from 1 to 16, each complementary pair will sum 17; 1+16, 2+15, 3+14, and so on.

This classification shows the existence of 12 different types, some of which are very curious. The most perfect of them is the *nasik* square. [For definition of a nasik magic square, see *foot-note*, in Knowledge, p. 277.] Of this type (which I call A) it can be mathematically proved that only 48 variations are possible. I give an example on the next page.

A

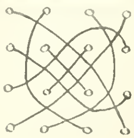


10	15	4	5
8	1	14	11
13	12	7	2
3	6	9	16

The diagram on the left shows the relative position of complementary numbers, a line in each case running from one to the other.

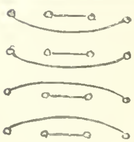
The remaining 11 types, with examples, are as follows:—

B



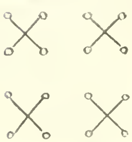
1	15	12	6
8	10	13	3
14	4	7	9
11	5	2	16

C



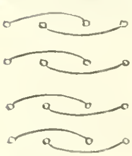
5	2	15	12
11	16	1	6
10	13	4	7
8	3	14	9

D



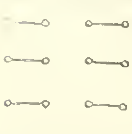
13	11	8	2
6	4	15	9
3	5	10	16
12	14	1	7

E



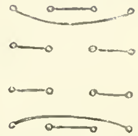
1	7	16	10
14	12	3	5
11	13	6	4
8	2	9	15

F



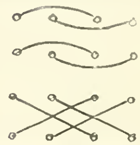
1	16	7	10
11	6	13	4
14	3	12	5
8	9	2	15

G



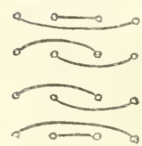
8	5	12	9
13	4	1	16
3	14	15	2
10	11	6	7

H



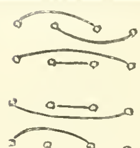
16	15	1	2
4	3	13	14
5	10	8	11
9	6	12	7

I



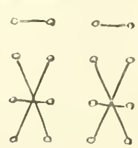
5	13	4	12
16	8	1	9
3	11	14	6
10	2	15	7

J



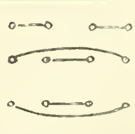
8	16	9	1
13	5	12	4
2	10	7	15
11	3	6	14

K



4	13	3	14
5	8	10	11
16	1	15	2
9	12	6	7

L



1	16	3	14
12	7	10	5
13	2	15	4
8	9	6	11

The above types are distributed amongst the 880 squares in the following proportions :—

Of type	A	there are	48	varieties
,,	B	,,	48	,,
,,	C	,,	272	,,
,,	D	,,	96	,,
,,	E	,,	96	,,
,,	F	,,	96	,,
,,	G	,,	52	,,
,,	H	,,	8	,,
,,	I	,,	52	,,
,,	J	,,	52	,,
,,	K	,,	8	,,
,,	L	,,	52	,,
			880	

There is a close connection between some of the types, especially between those of which there is the same number of varieties. A simple transposition of the figures will in many cases convert one into another. As an instance of this, types G, I, J, and L are thus reciprocally convertible. If we take a G square and transpose the two middle rows, and then the two middle columns, it is turned into a square of the I type ; and if this I square has its numbers diagonally adjacent to each other (like those connected in diagram D) transposed, we get a square of type J. If, further, this J square has its middle rows and columns transposed, a square of type L is formed ; and, once more altering the result like diagram D, we finally get the same square of G with which we started, but turned upside down.

One way of estimating the number of squares of a given type is to decompose the numbers into two skeleton squares, each containing four numbers four times repeated. By way of example, let us decompose a square of type C, being the most numerous, putting the numbers 1, 2, 3, 4 into one and 0, 4, 8, 12 into the other skeleton square ; thus :—

1	6	11	6		1	2	3	4		0	4	8	12
15	12	5	2		3	4	1	2		12	8	4	0
14	9	8	3		2	1	4	3		12	8	4	0
4	7	10	13		4	3	2	1		0	4	8	12
	(1)					(2)					(3)		

(1) is a square of type C ; and (2) and (3) are two skeleton squares which on being added together produce (1).

Now, on examining the structure of the squares (2) and (3), we see that their own complementary pairs are arranged in accordance with the type of (1), that is C. In (2) the sum of each pair is 5 ; in (3) the sum is 12. On further examination of the squares, we may observe that the numbers may be transposed in various ways so as to produce different results, still belonging to the same type. Thus, in square (2) each 2 may be written 3, and *vice versâ*, and each 4 may be written 1, and *vice versâ*. This will give in combination with square (3) three additional squares of the same type, or four in all.

Furthermore, the numbers in square (3) may be transposed in similar manner, 4 for 8 and 0 for 12, and *vice versâ*, giving another 4 varieties, which, combined with the 4 varieties of the other skeleton square, give us 4×4, or 16 squares of the type. Again, the arrangement of the two skeleton squares may be reversed ; we may write down the 1, 2, 3, 4 in the way the 0, 4, 8, 12 are written down above, and *vice versâ*. This doubles the number of squares producible, giving us 16×2, or 32. Once more, a partial transposition may be made in the numbers of square (2). For example, the 2 and 3 may be transposed in the top and bottom rows, whilst those in the middle rows are undisturbed.

This partial transposition may be performed on whatever numbers occupy the middle cells of the top and bottom rows. This again doubles the number, bringing it up to 32×2, or 64.

Nor is this by any means all. There are two other ways of decomposing these squares. Instead of putting 1, 2, 3, 4 into one, and 0, 4, 8, 12 into the other skeleton square, we may put 1, 2, 5, 6 into one, and 0, 2, 8, 10 into the other ; or 1, 3, 5, 7 into one and 0, 1, 8, 9 into the other. Thus

1	2	5	6		0	2	8	10		1	4	13	16
5	6	1	2		10	8	2	0		15	14	3	2
2	1	6	5		10	8	2	0		12	9	8	5
6	5	2	1		0	2	8	10		6	7	10	11
	(4)					(5)					(6)		
1	3	5	7		0	1	8	9		1	4	13	16
5	7	1	3		9	8	1	0		14	15	2	3
3	1	7	5		9	8	1	0		12	9	8	5
7	5	3	1		0	1	8	9		7	6	11	10
	(7)					(8)					(9)		

The second set of series in (4) and (5), and the third set in (7) and (8), have just the same arrangement respectively as the numbers in (2) and (3). The resulting squares (6) and (9), it may be noticed, are different from (1) and different from each other. Using all these three sets of series therefore trebles the number of squares previously arrived at—giving us 64×3, or 192. These 192 squares, however, do not exhaust the type C. I am indebted to Mr. James Cram, the author of an ingenious little book on magic squares, for five other squares of this type, each of which may be transposed in all the ways above described excepting two, thus producing 16 varieties of each instead of 64. This gives us 5×16, or 80 additional squares—making up the 272. I give below the analysis of one of these 80, as it is very peculiar :

1	5	12	16		1	1	4	4		0	4	8	12
15	11	6	2		3	3	2	2		12	8	4	0
14	8	9	3		2	4	1	3		12	4	8	0
4	10	7	13		4	2	3	1		0	8	4	12
	(10)					(11)					(12)		

The skeleton squares (11) and (12), it will be observed, both sum wrongly in their diagonals. Nevertheless, on combination, the resulting square is found to be correct ; the errors having an opposite character, and neutralising one another.

The decomposition of squares is easily effected by aid of little tables like the following :—

	1	2	3	4			1	2	5	6			1	3	5	7
0	1	2	3	4		0	1	2	5	6		0	1	3	5	7
4	5	6	7	8		2	3	4	7	8		1	2	4	6	8
8	9	10	11	12		8	9	10	13	14		8	9	11	13	15
12	13	14	15	16		10	11	12	15	16		9	10	12	14	16

Find the number you wish to decompose in the table belonging to the series, and in a line with it will be found at the top the number for one of the skeleton squares, and at the left-hand side that for the other.

A PERPETUAL CALENDAR.

Mr. C. L. Prince, of Crowborough, has sent us a very simple perpetual calendar devised by him a few years ago, which avoids the necessity of committing to memory the rather complicated rules given in Mr. R. W. D. Christie's letter in our last number.

The accompanying block may be cut out and mounted on two pieces of cardboard. The inner circle of Domi-

nical letters and days of the month should be mounted on a circular piece of cardboard, affixed by a paper-fastener or button and thread through its centre to a larger piece of cardboard, on which the outer circle con-

taining the days of the week and months should be gummed concentrically with the inner disc.

Mr. Prince's rules for finding the day of the week corresponding to any date in this century, are as follows:—

A List of Sunday Letters from A.D. 1800 to 1899.

D	1	29	57	85	
C	2	30	58	86	
B	3	31	59	87	
A	4	32	60	88	G
F	5	33	61	89	
E	6	34	62	90	
D	7	35	63	91	
C	8	36	64	92	B
A	9	37	65	93	
G	10	38	66	94	
F	11	39	67	95	
E	12	40	68	96	D
C	13	41	69	97	
B	14	42	70	98	
A	15	43	71	99	
G	16	44	72		F
E	17	45	73		
D	18	46	74		
C	19	47	75		
B	20	48	76		A
G	21	49	77		
F	22	50	78		
E	23	51	79		
D	24	52	80		C
B	25	53	81		
A	26	54	82		
G	27	55	83		
F	28	56	84		E

"Rotate the Circular Index until you place the Sunday Letter for the Year under the Month you require, when it will show the day of the week for any day in that month, and will thus serve as a Calendar for any number of years. The Letters in the first column of the adjoining Table are the Sunday Letters for each year in the same line."

"In the case of Leap Year (to February 29th only), make use of the first of the two Sunday Letters for that year; thus, for the year 1888, A would be the letter to February 29th, and G for the remainder of the year."

"Each Letter in sixth column denotes that all years between it and that in column one are Leap Years. This table renders the Calendar useful for ascertaining the day of the week of any date during the present century."

The days of the week for next century may be at once determined by finding the day of the week for the corresponding day of this century, and going back two days; thus, the 1st of January 1801 was on a Thursday, and the 1st of January 1901 will be on a Tuesday. The days of the week for last century, from the 14th of September 1752, when the eleven days were dropped, till the end of the century, may be determined by finding the day of the week for the corresponding day of this century and going forward two days; thus, the 1st of January 1853 was on a Saturday, and the 1st of January 1753 was on a Monday.

To determine the days of the week for the twenty-first century we must go backwards three days in the week from the corresponding day of this century, for the year 2000 will be a leap year, while the years 1900, 2100, &c. are not leap years. For the twenty-second century the rule will be—go backwards five days in the week, which is the same thing as going forward two days.

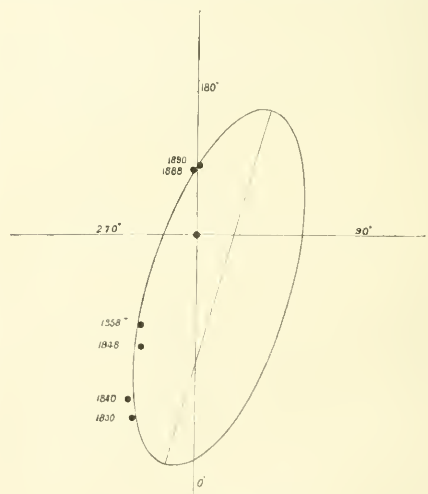
In the twenty-third century, people will keep the tetracentenaries, or fourth-century celebrations of events which have happened in this century, on the same day of the week as that on which they actually happened or are supposed to have happened.

In future all tetracentenaries will occur on the same day of the week as the event they commemorate, for a period of 400 years must always include one year which will divide by 400 without leaving a remainder.

NOTE ON THE ORBIT OF THE DOUBLE STAR Σ 2.

By S. W. Burnham.

It would have been hardly possible to get even an approximate orbit of this star with the measures made during the fifty years following its discovery. At the time of the first observations by Struve it was comparatively easy to measure; but the stars slowly approached each other, and after 1858 the measures are few and very uncertain. Many of the estimated, or partly measured position-angles are obviously very largely in error, judging from the earlier measures which may be assumed to be reasonably exact, since the distance between



Apparent orbit of Σ.

the components was sufficient to make it easily measureable with a moderate aperture. No attempt, so far as I am aware, has been made to compute an orbit from these measures. The entire angular motion from 1830 to 1858 was only 12°. The principal change was in the distance, which at the last-named date was only one-half that at the time of the first measures by Struve. So far as these observations are concerned, they could be as well repre-

sented by rectilinear motion as any other. The probabilities, however, in the case of a pair of this kind are greatly in favour of the relative change being due to orbital motion, and it was safe to assume that these stars were far more likely to be physically connected than that one was drifting past the other from proper motion.

In using the 36-inch telescope for double star work, as far as time would allow, I have looked up and re-measured some of the old pairs which have either been single for many years, or so difficult that they were practically non-measurable with ordinary telescopes. The result has been that in a number of instances a single set of measures of each star made it possible to get a reasonably accurate idea of the periods. In this case, the change in angle since the last measure of Otto Struve amounts to over 150°, so that the apparent path of the companion in the future is confined within narrow limits. I had overlooked, when placing this star on the working list, an excellent set of measures by Tarrant in 1888, made with a 12-inch reflector. These measures are remarkably accordant with my own made with a much more powerful instrument.

I have taken all the measures of this pair which can be used in any investigation of its motion, and laid them off accurately to scale (5 inches=1″), with the distance to the second decimal place, and the angles to the nearest tenth of a degree. As nearly as possible through these positions an ellipse has been drawn which will make the areas proportional to the times, and allow of the minimum correction of the observed angles and distances. The figure shown on the accompanying diagram is in substantial compliance with these conditions, and the errors of observation are practically insensible in measures of this kind.

The following are the measures made use of :—

1830	·85	341°·5	0″·81	Σ	5 n
1840	·56	338°·4	0″·71	OΣ	3 n
1848	·22	334°·9	0″·52	OΣ	6 n
1858	·50	329°·3	0″·44	OΣ	10 n
1880	·58	Certainly single		β	
1888	·09	182°·8	0″·3±	T	3 n
1890	·82	177°·1	0″·29	β	3 n

During the interval of about thirty years, in which there are no measures, it was frequently noted as single, and doubtless was apparently so with the instruments used ; but much of the time the distance must have been at least 0″·2, and of course this would have been noticed with a larger aperture. I have given above my own negative results in 1880, as the observation was made with the 18·5-inch of the Dearborn Observatory, and the distance must have been very small to have escaped detection. According to this orbit, at that time the distance should have been a little less than 0″·15, and so slight an elongation probably would not have been noticed with that aperture. With the Lick telescope it would have been measureable at all times.

It is not claimed that anything more than approximate results can be derived from these investigations, but the graphical method is probably as good as any other with the present data. It is evident that the period is a long one ; and according to this ellipse it would be about 450 years. We have also the following :—

Maximum distance - - -	0″·98
Minimum distance - - -	0″·13 (1876)
Major axis - - - -	1″·55
Minor axis - - - -	0″·58
Position angle of major axis -	164°·5

The change for some time will be mainly in distance. In about five years more it should be 0″·4 ; and it will then be easily measurable with almost any instrument. Frequent measures of a pair of this class are not necessary. A few careful sets of measures every five or ten years will be all that is required for any purpose.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

HOW DID HE FIND THE WAY?

To the Editor of KNOWLEDGE.

DEAR SIR,—If it will not trespass too greatly on your space, I should be glad if you could afford room for the following incident :—

In August 1889 a gentleman and his family removed from Stockport to St. Leonards-on-Sea, taking with them a fine Tom cat they had had several years. Tom seemed restless at this change of quarters, and, after about a fortnight, disappeared. Some weeks later, Tom's master received a letter from one of his sons who was resident in Stockport to the effect that Tom had been seen by the neighbours prowling round his old home. Shortly after, he disappeared again, and about three weeks later again arrived at St. Leonards in a very deplorable condition—reduced to a mere skeleton. His master, on returning home late one night, found the cat on the door-step, and was welcomed by him with every possible demonstration of delight. Tom has been very feeble ever since, and is most unwilling to leave the house.

The puzzle is, how could the cat find his way from St. Leonards to Stockport, a distance of 200 miles, seeing that he was brought by train, and was shut in a sack for most of the way. And to make the puzzle yet more difficult, the railway journey was necessarily broken in London, and the cat was conveyed from the northern to the southern station in a cab. The return journey to St. Leonards one can understand, but how did he find his way to Stockport ?—E. W. MAUNDER.

[The weak link in this remarkable story seems to be that Tom was only seen and recognised by the neighbours, prowling round his old home. A recognition by the son would have been more satisfactory, especially if he had marked Tom. A. C. RANYARD.

I have made inquiries, and find that—

1. The intimation that the cat had appeared in Stockport was an independent one, *i.e.* before the people at Stockport knew that the cat had been missed at St. Leonard's.

2. The cat was away just over seven weeks in all, and was seen at Stockport during the middle week of the seven.

3. The cat was seen, recognised, fed, and taken care of by the next-door neighbours of its owners. The son resident in Stockport was unfortunately unable to come to identify the cat until after it had set out on its travels again.

4. The cat, which was formerly very fine and healthy, has suffered ever since from severe bronchitis.

5. Neither the owners of the cat nor the neighbours have the slightest doubt as to its identity. Indeed they are disposed to be rather indignant if it is hinted that there may be the possibility of a mistake.

If it was *not* the same cat that turned up at Stockport, then there certainly were some remarkable coincidences.

E. W. MAUNDER.

THE MILKY WAY IN THE SOUTHERN HEMISPHERE.

By A. C. Ranyard.

THE plates illustrating this paper have been made from photographs taken by Mr. Russell, Director of the Sydney Observatory, New South Wales. They will bear close examination with a magnifying glass, and the sharp images of the small stars show how very accurate and steady must have been the motion of Mr. Russell's driving clock, which kept the camera directed to the stars during the exposures by a motion about the polar axis of the instrument in a contrary direction to the earth's motion about its axis. The driving clock was controlled by an electrical apparatus, contrived by Mr. Russell, which connects it with a governing clock and two heavy pendulums. These photographs form a very satisfactory certificate of Mr. Russell's method of electrical control, and show that the differences of refraction due to the changes of the altitude of stars during long exposures may be more accurately compensated for than had hitherto been supposed.

The scale of these star-pictures will be best appreciated from photograph No. II., which shows the greater part of the lower or southern portion of the constellation of Orion. The three stars at the bottom of the picture form the belt of the constellation giant. The three stars in a nearly vertical line above them, with the Great Nebula about the central star, form the sword; and the two stars on either hand towards the top of the picture form the feet of the giant. Unfortunately the printers have turned this picture, as well as No. III., with the south point at the top instead of at the bottom of the pictures, as in Nos. I. and IV.

Picture No. II. enables us to show that the central line of symmetry of the Orion Nebula, towards which the great curving structures springing from the neighbourhood of the trapezium are synclinal, is, as nearly as one can judge, at right angles to the medial plane of the Milky Way. A reference to any good star map or globe showing the Milky Way, will show that the line passing through the stars of Orion's Belt is nearly parallel to the plane of the Milky Way, the axis of symmetry of the Great Nebula is nearly square to the line of the belt, and consequently at right angles to the general plane of the Milky Way. Another fact worth mentioning, as showing an apparent symmetry with regard to the plane of the Milky Way, is that the two remarkable nebulous lines joining stars in the Pleiades Nebula* are approximately parallel to the general plane of the Milky Way, though neither of the lines are quite straight or parallel the one to the other. The edges of the great curving structures of the Orion Nebula are all harder on the inside towards the axis of symmetry which passes through the trapezium, and softer or more nebulous on their outer or convex edges. The scale of picture No. II. is too small to show this, though it is partly shown on the larger picture published in the May number of Knowledge for 1889, and referred to in the accompanying article on the Nebula. It is still more evident on the original negatives, and would alone prove, even if we knew nothing of the symmetry of curvature of the tree-like structures which spring from the trapezium region, and of the canopy which overhangs the whole nebula, that there are mighty forces acting towards and away from the axis of symmetry—that is, parallel to the plane of the Milky Way.

It will be remembered that both the Pleiades Nebula and the Orion Nebula lie a little to the south of the Milky Way, at about the same distance from its medial plane. There seems to be no obvious connection between the plane in which the Great Nebula in Andromeda lies and the plane of the Milky Way, and the same remark applies with regard to the Ring Nebula in Lyra. The elliptic patches of light into which these nebulæ project have not their major and minor axes parallel and perpendicular to the medial line of the Milky Way, as would be the case if the planes of these nebulæ were either parallel or perpendicular to the plane of the Milky Way; but though these two nebulæ are both on the borders ot the Milky Way, the spiral nebulæ do not seem to be associated with the Milky Way in the same intimate manner that the other large and irregular nebulæ are; thus the spiral nebulæ in Ursa Major and Canes Venatici are at some distance from the Milky Way, and their planes are evidently not parallel to one another. Even the small elliptic nebulæ H.V. 18, discovered by Miss Caroline Herschel close to the great Andromeda Nebula, evidently lies in a different plane from the Great Nebula.

Picture No. I. represents the part of the Milky Way in Sagittarius photographed by Mr. Barnard, which we reproduced in the July and August numbers of Knowledge. The differences between Mr. Russell's photograph taken at Sydney on the 2nd October 1890, and Mr. Barnard's photograph taken at the Lick Observatory on the 1st August 1889, are very curious and worthy of close attention. Both photographs were taken with six-inch portrait lenses of about 31 inches focus, so that they are on about the same scale, and the pencil of light falling on the sensitive plate was in each case of about the same intensity. Mr. Barnard's photograph was exposed for 3h. 7m., and Mr. Russell's for 4h. 2m. Nevertheless, Mr. Barnard's photograph shows much more of the nebulous structure of this region of the Milky Way than Mr. Russell's. This might be due to differences in the method of development, or to a difference in the sensitiveness of the plates used (Mr. Russell seems to have used Ilford extra rapid plates; and Mr. Barnard, I believe, used some plates prepared by the American Seed-plate Company). But it is remarkable that the relative brightness of the nebulous areas on different parts of the plates do not correspond with one another on the Russell and Barnard plates. The reader should refer to the large picture from Mr. Barnard's negative published in the July number of Knowledge in order to follow what I am about to say. He will then see that there are great differences in the brightness of different parts of the nebulous structure, while the relative brightness of the stars is much the same on both the plates—with one notable exception, which it may be well to draw attention to before referring to the differences in the brightness of the nebulous light.

In Mr. Barnard's picture there are two clusters of stars near to the edge of the field at the bottom of the plate. Only one of these clusters, viz. that to the right hand or western side of the field, is shown in Mr. Russell's plates. The almost equally brilliant cluster near to the bottom of Mr. Barnard's plate is missing in the Sydney photographs, for Mr. Russell has sent over silver prints from two negatives, one taken on the 17th September 1890, and the other, reproduced in our picture No. I., taken on the 2nd October 1890. I at first thought it possible that both photographs might by mistake have been copied from the same negative, and that the differences between the Lick and Sydney photographs might possibly be due to inequalities in the sensitiveness of different parts of the film of Mr. Russell's plates. But it is evident that no

* *See* Knowledge for January 1889, pp. 69–70.

Preceding.

Preceding.

I.—Photograph of the Milky Way in Sagittarius.

Following.

II.—Belt and Sword of Orion, showing Great Nebula.

Preceding.

Following.

III.—Photograph of the Nebecula Major.
Taken by H. C. Russell, 17th Oct. 1890. Exposure, 7h. 3m.

Following.

IV.—Photograph of the Nebecula Minor.
Taken by H. C. Russell, 14th–15th Oct. 1890. Exposed 8h.

such mistake can have been made, for Mr. Russell's photograph of the 2nd of October contains a trace made by the planet Mars during the exposure, while the photograph we have here reproduced does not. There seems, therefore, to be no doubt that we have two independent photographs, and we seem to have evidence of very rapid change in the brightness of the southernmost of these two star-clusters.

While the nebulosity in the upper part of Mr. Russell's picture corresponds generally with that in the upper part of Mr. Barnard's picture, making allowance for differences of sensitiveness of the plates used, that in the middle and lower parts does not. The brightest* nebulous region in Mr. Barnard's picture is on the right-hand side of the tree-like form which stretches across the middle of the plate at the base of its lowest right-hand branch. But this bright region is entirely wanting in Mr. Russell's photographs, as also is the very bright nebulous region to the left-hand side of the base of the great tree-like structure. It is, of course, possible that such differences might be due to the nebulosity of the upper part of the tree-like structure being caused by a stippling produced by larger stars than those which give rise to the nebulous appearance on the lower part of the plate, and that while the small stars have left their trace on Mr. Barnard's plate, only a larger grade of stars have impressed themselves sufficiently to leave a developable trace on Mr. Russell's plate. It is also possible that the lower part of the nebulous mass may shine with a different kind of light from that with which the upper part shines, and that while Mr. Barnard's plates were sensitive to both kinds of light, Mr. Russell's were only sensitive to the one. But it is also possible that we may here have evidence of the existence of a vast variable nebula which undergoes changes in the relative brightness of its parts with surprising rapidity.

I should like to call attention to the fact that the branching tree-like form shown in Mr. Barnard's picture (the upper part of which appears in Mr. Russell's pictures) seems to afford us evidence of the projection of matter into a resisting medium just as certainly as the tree-like forms in the great Orion Nebula and the tree-like forms † in the Corona bear witness to explosions on a colossal scale, which have taken place below their bright bases, causing a stream of matter to be projected upwards, which stream has subsequently been divided and its branches deflected from their original course by a resisting medium. If there were no resisting medium and the only force acting on the projected matter was gravity towards the region from which the explosion took place, the streams would have the form of trajectories, and they could only be projected into conic sections.

The actual existence of the great tree-form on Mr. Barnard's picture seems to be confirmed by the arrangement of the stars in lines along its branches, which is best shown in the small photographs published in the August number of Knowledge for 1890, and in the *Monthly Notices* of the Royal Astronomical Society for March 1890. To see the stars in these small pictures they should be examined with a magnifying glass. The brighter streams of stars will be recognized in Mr. Russell's photographs after they have once been seen in Mr. Barnard's.

We seem, therefore, to have evidence that there is a resisting medium which occupies a vast region of the Milky Way; and perhaps the whole nebulous circle which surrounds the sky is not one vast nebula. The resisting medium need not be gas; dust moving in space, or larger particles, would equally offer resistance. The variability in brightness over so vast a region, if substantiated by future photographs, will need us to assume the existence of forces travelling far more swiftly than light or electricity, and giving rise to the synchronous dimming or glowing of the light-giving matter.

Picture No. III. represents the Nebecula Major (the larger Magellanic cloud), taken by Mr. Russell on the 17th of October 1890 with an exposure of 7h. 3m. In a private letter enclosing me the silver print of this picture Mr. Russell says: "This negative has brought out the grandest spiral structure in the heavens. Herschel estimated this object to cover 48°. It is now shown to be one great spiral structure supported, as it were, by two smaller ones in which *stars only* are visible. One is situated on the *North following*, and the other on the *South preceding* side of the great spiral." These spirals are just visible on our plates, but they are not so well shown as on the silver print or on the transparency which Mr. Russell has kindly sent me.

Picture No. IV. represents the Nebecula Minor, taken on October 14–15, 1890, with an exposure of 8 hours. It is also spiral in structure, though not so clearly so as the Great Nebecula. Within it and around it are some curious streams of small stars, all of about the same magnitude. One of such streams, shown in our plate on the upper left-hand side of the chief cloudy mass, is like a double W.

Mr. Russell has also sent over a most interesting contact print from a negative of the Coal-sack region. Instead of being a completely closed space, it is seen to be open on the south side, and very numerous small stars are seen to be scattered over three-fourths of its area. It is only at its northern part that there is the absolute absence of stars so frequently referred to by Mr. Proctor.

* The nearly circular white patch at the top of the picture is, as was explained in the July number, due to an over-exposed image of the planet Jupiter, with the Trifid Nebula below it. Jupiter has moved away and the Trifid Nebula remains on Mr. Russell's pictures.

† See Knowledge for May 1889, p. 146.

Notices of Books.

The Physical Properties of Gases. By Arthur L. Kimball, of Johns Hopkins University. (William Heinemann, London. 1890.) Professor Kimball's book will be welcomed as giving, in simple, untechnical language, and in a manner easily to be comprehended by the non-mathematical section of the community, the reasoning by which physicists have been led from the properties of gases as they were discovered by experiment to the present generally accepted kinetic theory of their constitution. After having given in brief outline a history of the discovery of some of the more important gases and their behaviour under pressure and expansion by heat, Prof. Kimball deals with the easily condensable vapours, and the gases which do not obey Boyle's law. He then treats of air-pumps and diffusion and occlusion. Avagadro's law that equal volumes of all gases, under the same conditions of temperature and pressure, contain the same number of molecules, is illustrated and explained in a manner that must make it clear to the most obtuse. Crookes's experiments with high vacua and radiant matter are also well explained and illustrated. It is, perhaps, a pity that Prof. Kimball does not go a little further and show, as he might have done in an elementary manner, how the average velocity of the molecules of a gas may be determined from its density when the pressure which it exerts at a known temperature is measured, and how the number of molecules may be

estimated from experiments on the diffusion and viscosity of gases. One of the most striking illustrations in the book is given in the chapter describing Sprengel pumps and high vacua. He says, "These high exhaustions are called by courtesy vacua, as they are the nearest approaches that physicists have been able to make to an absolute vacuum by the most refined methods known to science; and yet we should hardly call that space a vacuum in every cubic inch of which there are 350 million million molecules of the gas; and, according to the latest conclusions of the molecular theory, that is about the number in a cubic inch of air when it is reduced to one-millionth of the atmospheric pressure. To form some conception of the vastness of this number, we may consider that if, through the side of a little glass bulb of one cubic inch capacity that had been exhausted to this extreme degree, a hole were to be made through which a million molecules could enter in every second, it would take ten years for the pressure inside the bulb to be doubled; that is, for as many more molecules to pass through as those already contained in the bulb." Unfortunately, the book does not contain an index.

The Criminal. By HAVELOCK ELLIS. (Walter Scott, 1890.) During the last fifteen years the study of criminal anthropology has been carried on with great activity, and the rich harvest of facts which has already been collected is likely to lead to valuable conclusions, which may probably in the future enable us to deal more wisely with the criminal residuum that will always exist in a civilised society, in spite of school boards and free libraries and the other panaceas of certain theorists and philanthropists which are constantly proclaimed, like the patent medicines of the advertising quack, as a cure for all ills, social and political. The sentimentalist, who generally sympathises so much more with the notorious criminal than with his poor neighbour or relation, will be surprised to read what Mr. Havelock Ellis says about the physical sensibility of the criminal classes. He instances the wide prevalence of tattooing among them, frequently of the most sensitive parts, which are rarely tattooed amongst barbarous races, as showing the deficient sensibility of criminals to pain. Lauvergne mentions a convict who smiled with pleasure when, moxas having been applied to him, he saw his skin burning and heard it crack. Though loud in their complaints of trivial ailments, they are often unconscious of severe illness. At Chatham, in 1888, a prisoner dropped down dead on returning from labour; both lungs were found to be affected, and death was probably due to syncope. He had made no complaints to anyone. Prisoners will inflict severe injuries on themselves in order to gain some trifling object. At Chatham in 1871-72, 841 voluntary wounds or contusions are recorded; 27 prisoners voluntarily fractured a limb; and 17 of them had to submit to amputation; 62 tried to mutilate themselves, and 101 produced wounds by means of corrosive substances.

BIRDS AND BERRIES.

By the REV. ALEX. S. WILSON, M.A., B.Sc.

NATURAL History furnishes many curious illustrations of the mutual relationships subsisting between the animal and vegetable kingdoms. Of these we have remarkable examples in the well-known adaptations of flowers to the visits of insects. It is of the highest importance to a plant to have its seeds properly crossed, and this involves the transference of pollen from one flower to another of the same species. Insects frequenting flowers get dusted with this substance; they carry it with them to other flowers, where some of it adheres to the stigma prepared for its reception. The honey is not provided merely to gratify the bees, but as an inducement to them to visit the flowers and effect their fertilisation. A flower, in fact, is little more than an apparatus for securing cross-fertilisation. The scent and colour serve to guide the insects, while the shape of the flower is generally such that the bee cannot reach the honey without effecting the object for which it has been attracted.

Insects are not, however, the only animals to which plants are thus related. A considerable number of flowers appear to be adapted to birds rather than to insects. Humming-birds in America, sun-birds in Africa and India, the Malayan lories, and the Australian honey-eaters, visit flowers and effect cross-fertilisation very much as butterflies and bees do in Europe. The bird-fertilised class includes species of Fuchsia, Passiflora, Salvia, Abutilon, Impatiens, Lobelia, Marcgravia, Erythrina, and Cassia. Ornithophilous, or bird-fertilised, flowers are generally of large size, tubular in form, and secrete abundant nectar. Their colours are extremely brilliant, scarlet being perhaps the most frequent. Flowers of this description are rarely produced by herbaceous plants; they occur, as a rule, only on shrubs and trees.

Birds are employed to carry seeds much more frequently than for the transport of pollen; these bird-fertilised flowers have, however, a special interest as throwing light on the relations between birds and coloured fruits.

Fruits and seeds constitute a large proportion of the food of many animals; but if any animal were systematically to consume the seeds of a particular plant, the latter would run no small risk of extermination. To the animal itself this would be a serious misfortune if thereby it were deprived of its usual food. In the interest of the plant, as well as of the animal supported by it, some limitation to the consumption of seeds is necessary. Hence many plants conceal their seeds; in other cases these are obscurely coloured or encased in hard shells in order that at least some of them may escape being devoured. Other plants have been able to avail themselves of the services of animals, and can thus reimburse themselves for the loss they occasion. In some parts of Africa visited by the late Dr. Livingstone the grasses of the pastures frequented by herds of antelopes had their seeds adapted for dispersion by these animals. This arrangement is a mutual benefit, for in disseminating the seeds of the grass the antelopes unconsciously provide for their own future. The same thing may be said of birds which feed on berries and other succulent fruits. These are useful to plants in scattering their seeds, and in return they receive the soft, sweet pulp of the fruit, with the prospective advantage of a future crop from their own sowing. In plants which employ birds for their dispersion the adaptation is seen in the succulence, sweet taste, and bright colour of the fruit; and in the hardness, bitter taste, and emetic or purgative properties of the seed. There are two perfectly distinct objects to be secured; the attraction of the birds, and the protection of the seeds. Hence the succulent portion is not as a rule the seed itself, but some part of the pericarp or wall of the fruit. Berries have the pericarp entirely succulent, the hard seeds being embedded in pulp. Drupes, or stone-fruits like the cherry, have only the outer layers of the pericarp soft; the inner wall of the fruit, called the endocarp, is indurated, and forms the stone enclosing

the seed or kernel. Where the seed is so protected, it may itself be comparatively soft. The pomegranate and gooseberry are exceptional in this respect, that the testa, or outer layer of the seed, is developed in a succulent manner, the central core of the seed being, however, hard. The strawberry has the top of the flower-stalk very much enlarged; the edible portion is, in fact, formed from the thalamus (or spreading portion of the stalk from which the flower springs), the fruits being the little yellow seed-like bodies studded over its surface. The raspberry and bramble, on the other hand, have a dry, conical thalamus, on which are arranged a number of drupes corresponding in structure to the plum and cherry. In the mulberry the succulent portion is furnished by the calyx, and in the apple and fig the hollow receptacle, or flower-stalk, supplies the food material. From the small size of the seeds of berries we may infer that they are adapted to be swallowed along with the pulp. In the larger drupes the size of the stones and their rough or jaggy exteriors, as seen in the peach-stone, seem to indicate that the intention here is to induce the bird to fly to a distance with the fruit, and after devouring the soft portion, to drop the hard endocarp containing the seed. Where a fruit is not intended to be eaten it invariably acquires a hard and dry character.

Fruits adapted to birds are for the most part sweetly tasted. They contain, in addition to sugar, organic acids and essential oils, which confer an agreeable or even delicious flavour to the fruit, and constitute an attraction to birds as powerful as the nectar of flowers is to insects. If these qualities appeared too soon there would be a danger of the seeds being removed before they were ripe. Accordingly the fruit remains sour until the seeds are matured.

Succulent fruits are brightly coloured, to be easily recognised from a distance. Conspicuousness may be increased, as in the clusters of the grape, rowan, and elderberry, by the massing together of the single fruits in groups, just as happens in composite and other flowers where the florets are crowded on a contracted inflorescence. The colour of the fruit in general presents a strong contrast to the foliage. If the fruit remain on the tree after its leaves have fallen, its colour will challenge attention all the more as the season advances. The scarlet fruits of the wild rose thus remain on the bare branches and present a most conspicuous appearance. When the ground is covered with snow, coloured berries form prominent objects in the country landscape. Artists frequently avail themselves of this contrast, and introduce into snow scenes a sprig of holly with its scarlet berries. When Zeuxis painted the picture that deceived the birds, he may have taken advantage of this contrast; but perhaps it was left for Father Christmas to reveal to us how perfectly the colours of fruits serve the purpose intended by nature.

The list of plants bearing coloured fruits includes the following, which are British:—berberry, bittersweet, spindle-tree, strawberry, rose, hawthorn, currant, rowan, dogwood, honeysuckle, whortleberry, cranberry, bearberry, holly, daphne, arum, asparagus, lily of the valley, yew, alder, sloe, bramble, elder, bilberry, crowberry, juniper, misletoe, and snowberry; besides these, may be mentioned the orange, tomato, fig, date, olive, and mango. The colours of fruits are less varied than those of flowers. Possibly this may arise from the circumstance that while it is of importance, as regards fertilisation, that insects should be able to recognise and distinguish different species of flowers, there is no necessity for birds to distinguish different fruits, or to confine themselves to one kind of fruit, as insects restrict themselves for a time to one species of flower. Although never variegated like flowers, many fruits under cultivation exhibit a twofold colouration; thus we have red and green gooseberries, purple and green grapes, red and white strawberries and currants, green and purple plums, &c.

(To be continued.)

VARIABLE STARS OF THE ALGOL TYPE.

By Miss A. M. Clerke, *Author of "A Popular History of Astronomy during the Nineteenth Century," and "The System of the Stars."*

TEN stars of the Algol type are now known—ten stars, that is to say, which vary in light not so much physically as geometrically, through the accident of our point of view. They are, to begin with, very rapid binaries; but other binaries equally rapid shine with sensible constancy. It is only when the orbits of the revolving stars lie so nearly edgewise to the earth as to involve mutual occultations, that the peculiarity of a sudden loss of light at brief intervals is added to the peculiarity of composition into abnormally close systems. This has been spectroscopically demonstrated as regards Algol; and the other members of the class copy its phases with such fidelity as to leave no doubt that they too are genuine "eclipse stars." To argue the point would be to *enfoncer une porte ouverte*.

But this is not all. There are residual phenomena not amenable to explanation, simply by the recurring transits of a semi-obscure mass. Eclipses beyond question in all cases occur, and produce their due effects; yet complicated with others owning a different origin. Slight as these often are, their investigation offers perhaps the most promising clue to the labyrinth of stellar *physical* variability. For their evident connection with certain calculable phenomena of eclipse defines clearly the conditions under which they occur, and strongly suggests their origin through some form of mutual influence by closely revolving bodies, demonstrably of low average density. Moreover, the residual variations of Algol stars are of a nature tending to bridge the gap separating them from other variables. That is to say, the irregularities of light-change in the two orders show a very curious inverted correspondence, as if the same causes which produce darkening in the one set of objects produce brightening in the other. This unlooked-for circumstance can scarcely fail to become the guide to some important truth.

For eliciting it, however, observations both more detailed and better assured than those yet obtained are urgently needed; and it seems unlikely that they will be available until in this, as already in so many other departments of astronomy, the retina is superseded by the sensitive plate. The eye is nowhere more subject to illusion than in following the course of rapid luminous fluctuations; and its disabilities are not removed by any kind of auxiliary apparatus. Its very powers of adaptation, indispensable to it as a living organ, serve to impair its usefulness as a photometer. The stars, then, must register their own changes, and the method of photographic trails appears eminently suitable for the purpose of inducing them to do so. Professor Pickering has shown that comparative measures of different stars made in this way are reliable to about one-tenth of a magnitude; and discriminations based upon the varying width and intensity of successive sections of the same trail might be expected to reach a still higher grade of precision. Some practical difficulties would certainly have to be met, but probably none that would prove insuperable. Thus, an arrangement might be contrived for automatically, at fixed

intervals, moving the telescope in right ascension by the width of its own field, while the plate was simultaneously shifted 20″ or 30″ in declination. A series of parallel trails would result, exhibiting with absolute fidelity the gradations of loss or gain of light by which an Algol star traversed a critical stage of its minimum. Although exposures covering the whole of any one minimum could rarely be obtained, the comparison of trail-pictures of various sections of successive minima would be almost equally instructive. The realization of this plan would seem to be of considerable importance for the study of variable stars, and may safely be left to the ingenuity of celestial photographers.

The eclipse-theory of stellar light-change possesses little elasticity. Its explanatory powers are well defined, and incapable of extension. In the first place, the progress of the variations which it can account for must be along a smooth curve. There can be no stoppages or interruptions. Again, the amount of change must be invariable. High and low minima might, indeed, very well alternate in the same star, although they have not yet been found to do so: but capricious deviations from the assigned measure of obscuration are inadmissible. They seem, nevertheless, occasionally to occur. S Cancri and U Ophiuchi have each been once observed to lose far more than the usual proportion of their light; and M. Dunér recorded, at Upsala, November 25 and December 7, 1890, two abortive minima (as they might be called) of Y Cygni, when the star dropped to the extent of scarcely five, instead of eight tenths of a magnitude.*

Besides these anomalies in the measure, there are anomalies in the mode of change, which are equally perplexing and more persistent. The curves graphically representing it are unsymmetrical in at least seven of the Algol stars.† Their light, in other words, varies at a different rate before and after minimum. This is obviously incompatible with the progress of an eclipse by a body moving in an approximately circular orbit. And marked ellipticities are impossible (as Professor Pickering long ago pointed out in the case of Algol) where the conjoined stars are in such proximity as to leave no room for considerable oscillations about a mean distance already perilously small.

But indeed no amount of eccentricity in the paths traversed could satisfactorily account for the observed peculiarity. To begin with, the retardation does not advance continuously; in three or four of the stars a pause is indicated, followed by a resumption of progress. Moreover, the observed irregularities are of an invariable type; they take the form of a delay in recovery after minimum. It is *always* the ascending branch of the curve which is lengthened.‡ In order to explain this remarkable circumstance on gravitational principles, we should need the wholly unwarrantable assumption that *all* the stars in question passed periastron before falling under eclipse. Such a concurrence of coincidences is of course highly improbable.

Look, besides, at the minimum curve of U Ophiuchi depicted in Fig. 1, from the mean of 295 observations by Mr. Chandler.

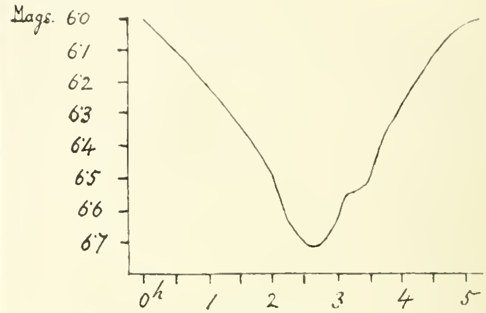


FIG. 1.—MINIMUM of U OPHIUCHI. From 295 Observations by Mr. S. C. Chandler.

The singular inflection of its ascending line is vouched for, as an objective reality, by the independent determinations of Messrs. Chandler and Sawyer (*Astronomical Journal*, No. 177), and often appeared more conspicuous in individual phases than as it emerged from the average of many. The possibility of regarding it as an effect of orbital retardation is at once excluded by the fact that, on the whole, there is no delay. Accelerated progress before and after the pause is so exactly compensatory that the duration of recovery just equals the duration of decline, notwithstanding irregularities in the rate of one as compared with the rate of the other.

Here, then, evidently, we have a physical cause of obscuration co-active with the geometrical one, and travelling in its train. Conjectures as to its nature hence naturally associate themselves with the enormous tidal strains necessarily prevalent in systems of such peculiar construction as those of Algol and its congeners. From these extensive deformations of figure must result in both members of each revolving pair; but the effects upon light-change are not easily unravelled, and, indeed, depend to some extent upon what we know nothing about, the mode of axial rotation of the stars concerned. On this point the simplest, and perhaps most probable, hypothesis is that they have none relatively to each other. If this be so, they move as if *spitted* together; there is no travelling tidal wave, but each body has the permanent form of an ellipsoid with three unequal axes, the longest centrally directed towards the companion-star. The widest expanse of luminous surface would, under these circumstances, be presented to our vision a quarter of a revolution before, and a quarter of a revolution after each eclipse, when slight maxima should occur, with corresponding intermediate minima. And the matching of these theoretical by actual effects in λ Tauri, and perhaps also in Algol, is suggested by some recent observations of M. Plassmann, needing, however, to be confirmed before

* The exceptional minima of all these three stars have been recorded on excellent authority. U Ophiuchi is No. 6,162 of Schjellerup's Copenhagen Catalogue, and was suspected by him of variability, on the ground of his careful observation of it, June 9, 1863, as of 7·7 magnitude, while Lalande had put it at 6, Bessel at 7 magnitude. The regular course of change of the star, since ascertained by Mr. Sawyer, is from 6·0 to 6·7 magnitude once in every 20·3 hours. Of S Cancri the usual range is from 8·2 to 9·8 magnitude. Nevertheless, Schmidt observed it at Athens, April 14, 1882, to remain stationary for a whole hour at 11·7 magnitude (*Astr. Nach.*, No. 2,491). In his determinations of Y Cygni, Dunér used Chandler's comparison-star *p*, of 7·8 magnitude in the *Durchmusterung*, and exempt from any suspicion of change. At all the minima observed by Chandler and Yendell, Y Cygni sank decidedly lower than this star; but on the two occasions mentioned in the text Dunér found it to remain two steps (about one-fifth of a magnitude) brighter, and concluded, on apparently strong evidence, its phases to be inconstant (*Astr. Nach.* No. 3,011).

† These are: Algol, S Cancri, δ Libræ, λ Tauri, U Cephei, U Ophiuchi, and U Coronæ. S Antliæ will probably be added to the list; and we are unacquainted with particulars as to the phases of Y Cygni and R Canis Majoris.

‡ Although the curve of U Cephei (*see* Fig. 2) shows a slight pause *before* minimum, the whole time of recovery considerably exceeds that occupied by the decline in light.

much stress can be laid upon them. He, too, has recourse in a general way to the tidal rationale; and—what is more significant—ranks λ Tauri as a transition instance between Algol and β Lyræ, adding the remark that spectroscopic measures of its radial movements may help to elucidate the still unfathomed mystery of "short-period" variability. (*Astr. Nach.*, No. 3,016.)

A cause tending further to complicate tidal phenomena in sun-like bodies has been adverted to by Mr. Ranyard. It is this. A photosphere is probably a region of condensation, or the hottest region where matter can exist in a non-gaseous form. Consequently the temperature of the photospheric region is fixed. It may be regarded as an isothermal surface changing its level with local variations of heat. The photospheres, accordingly, of two adjacent radiating masses should bulge out somewhat, one towards the other. Deformations arising in this way in the Algol stars might be expected to become sensible to our perception—if at all—after a similar fashion to tidal deformations, namely, by maxima of lustre at elongations, minima at conjunctions.*

Neither source of disturbance, however, connects itself naturally with the enigmatical pause in recovery characteristic of this class of variables. And the late M. Klinkerfues's supposition of an atmospheric tidal wave following in the wake of the satellite, and bringing about partial obscurations through increased absorption, receives no countenance from the spectroscope. The light of U Cephei, it is true, turns ruddy as it fades; but not, it may safely be asserted, owing to this cause. The variations of its spectrum offer a tempting and hitherto unexplored field of study. Indeed, the star has of late in every way, especially in this country, been too much neglected. It is remarkable for a prolonged minimum, originally explained by Professor Pickering as due to a total eclipse by a large, semi-obscure satellite. But Mr. Chandler's observations showing variations of about two-tenths of a magnitude during the supposed totality, seem to compel recourse to some other hypothesis, if not to replace, at any rate to supplement the first. Two periods of the star being nearly equal to five days, only every second minimum can be followed at the same season of the year. Those of which the average course is represented in Fig. 2 occurred in the autumn. A shorter spring series of observations, also by Mr. Chandler, giving almost a dead level of least light, of close upon two hours' duration, claimed an inferior degree of authority (*Astronomical Journal*, No. 199). There is probably no real distinction in character between the alternating phases.

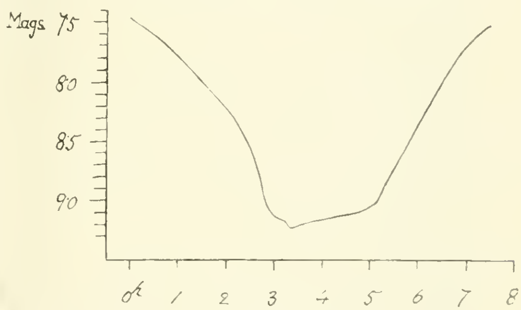


Fig. 2.—Minimum of U Cephei. From 159 autumn observations by Mr. S. C. Chandler.

The vicinity of this object to the pole renders it particularly suitable for "trailing" experiments, which might definitively settle the interesting question as to the true form of its light-curve.

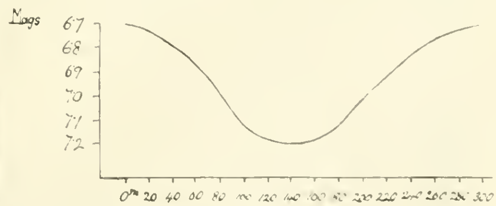
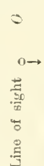


Fig. 3.—Provisional Minimum-Curve of S Antliæ (Yendell).

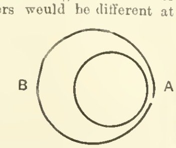
Since tidal effects grow, *cæteris paribus*, in the inverse proportion of the cube of distance, they ought, so far as they influence luminosity, to be most apparent in variables of the shortest periods, since these are proved by the proportionate length of their eclipses to be made up of the most closely contiguous pairs. But there is no sign that the subsidiary changes of Algol stars obey any such law. They are especially striking in S Cancri, with its relatively long period of nine and a half days.

* If we suppose the larger star to have given birth to the smaller eclipsing star, in a manner similar to that suggested by Prof. Geo. Darwin with regard to the birth of the moon from the earth, we should expect to find the larger star rotating on its axis faster than the smaller star completes a revolution about it; and the longest axis of the tidal ellipsoid would also, as in the case of the earth's tides, travel in advance of the line joining the centres of the two stars. Thus the larger star would present its minimum area before the time of inferior conjunction or central eclipse.



But there is another possible cause of variation in the light derived from the eclipsed star, which was not overlooked by Prof. E. C. Pickering in his remarkable paper on the "Dimensions of the Fixed Stars, with special reference to Binaries of the Algol type," published in the *Proceedings* of the American Academy, Vol. XVI., viz. the probable decrease of the brightness of the discs of stars towards their edges. Prof. Pickering says: "The presence of lines in stellar spectra leads to the belief that the stars, like our sun, are surrounded by an absorbing atmosphere. They also, therefore, probably resemble it in presenting a disc brighter in the centre than at the edges, owing to the greater thickness of the atmosphere and consequent greater absorption at the edges."

Prof. Pickering seems to have assumed that the decrease of brightness would be similar at both limbs, but with an egg-shaped star with the longer axis inclined to the line of sight the rate of increase of thickness of the absorbing layers would be different at the two limbs, and, under the conditions assumed above, we should have the decrease of light towards the preceding limb A more rapid than towards the following limb B; consequently the light of the larger star would recover its brightness more slowly just after central eclipse than it decreased before central eclipse.



According to my theory, the photosphere of a binary star would be intermediate in form between an isothermal surface and a surface of equilibrium, for, as explained in a former paper, we cannot suppose the photospheric clouds to be floating in an atmosphere. The particles must be falling under the action of gravity retarded but slightly, if at all, by gaseous friction, such as that which retards the fall of the particles composing a cloud in our atmosphere, but they would be retarded by the backward kicks of molecules evaporated towards the heated centre. Such falling particles would be finally evaporated at a level which would depend on the temperature of the region, as well as on their rate of falling; and since the acceleration of gravity would be similar at all places on a surface of equilibrium, and the temperature similar at all places on an isothermal surface, we should expect to find the falling particles glowing most vividly before their final dissolution in a stratum which would extend around the star as a thin shell intermediate in form between an isothermal surface and a surface of equilibrium.—A. C. Ranyard.

They are only doubtfully traceable in S Antliæ, notwithstanding the extreme swiftness of its revolutions. Mr. Yendell's provisional light-curve for the latter star, shown in Figure 3, regains its original level with scarcely perceptible retardation. Professor Paul, of Washington, the discoverer of this stellar prodigy, refrains for the present from pronouncing upon the reality of its suspected anomalies. Indications were, however, caught by him of a lagging after minimum, in the manner of U Ophiuchi and S Cancri, and he also records his impression of considerable inequalities both in the duration and intensity of its separate phases, a long, shallow curve occasionally replacing an undulation of wider amplitude and quicker accomplishment,* while both the loss and the gain of brightness appeared to proceed by accesses, rather than by an equable flow (*Astronomical Journal*, Nos. 215, 234).

The period of this star is by far the shortest known, either for a binary or a variable. According to Mr. Chandler, it retains its maximum brightness of 6·7 magnitude during 4h. 30m., sinks in about 1h. 40m. to 7·3 magnitude, and recovers with nearly equal rapidity; the whole period being of 7h. 46m. 48s. (*Astronomical Journal*, No. 218). Mr. Yendell's determinations, on the other hand, assign 5h. 10m. to the phases; but an eclipse extending over more than half the period of revolution is a manifest absurdity, only to be got rid of by doubling the latter,† and assuming the occurrence in each circuit of two mutual eclipses by equally bright stars. The reduction of light by about one-half at each obscuration renders this a plausible expedient, the adoption of which in nature can be tested by spectrographic means. A more powerful telescope than that at present in use at Potsdam would, however, be required to disclose the periodical doubling of spectral lines due to the possibly two-fold origin of the light we receive from S Antliæ.

A system is at any rate here presented to our consideration such as the boldest imagination could not beforehand have conceived. Even with a doubled period, the occulting twin-suns must revolve (if the data supplied by Mr. Yendell be accepted without modification) in so narrow an orbit relatively to their bulk, that the distance from surface to surface amounts to no more than $\frac{14}{100}$ of the distance from centre to centre. By reducing the time of light-change in accordance with Mr. Chandler's observations, a free space would be afforded of still much less than half the orbital span. The subsistence of such an arrangement cannot easily be reconciled with known mechanical laws; yet it seems undeniable.

* The well-known correlation of short with sharp sun-spot maxima offers a curious analogy with these significant indications.

† As suggested by Mr. Backhouse in the *Observatory* for October 1890.

NOTES FROM CAMBRIDGE.

By R. B. JOHNSON.

ANATOMY IN THE OLDEN DAYS.

THE turbulence natural to medical students and the popularity of Professors Macalister and Humphry combined to transform the new anatomical lecture-room into a scene of loud-voiced and inspiriting enthusiasm at Professor Macalister's opening lecture. He was commemorating the completion of the new buildings by giving a *résumé* of anatomical teaching in Cambridge from the days of the mediæval *studium generale* to the present time of elaborate sub-division.

The earliest record of a school of Physics at the University is in 1421, but the first definite provision for anatomical teaching was made by John Caius somewhat later in the same century. He was followed by W. Hardy in the sixteenth and by a brilliant galaxy of anatomists in the seventeenth centuries, of whom one instructed Newton, and another tried his hand at writing plays. From the time of Caius we were intimately connected with the Corporation of Surgeons in London, who sent us a scholar receiving £40 a year for his maintenance and £3 a year to provide himself with books. In order to qualify as a practitioner in those days it was necessary to have attended three dissections at which a body was opened, and "the physicians present discoursed at random concerning the interior."

The first separate professorship of Anatomy was founded at Cambridge in the year 1707, but the immediate effect of endowment appears to have been a cessation of all interest in the subject. It was the time of the Resurrectionists, however, and we read of the watchmen being allowed to search in Emmanuel for a missing body. This was illegal, be it remarked, and really an act of coercion, as may be seen from the following tale. A giant once died in Dublin, thereby exciting the desires of an anatomical professor and his students, to whom he said: "Gentlemen, I understand that your feelings are excited towards the seizure of this body, against which I must certainly counsel you. But in case your zeal should overcome your discretion, I will tell you the exact case of the law, which is, that you may take the body, but that for the removal of the least rag or shred of covering thereon you may be hanged. Therefore, if you *should* remove the body, be careful that it is utterly unclothed." Needless to say, that Professor was given the opportunity of experimenting upon that giant.

A more melancholy anecdote is associated with the memory of our own Professor Collignon, who once invited two friends to the dissection of a body, in which one of them recognised the features of an acquaintance. It was the body of Lawrence Sterne, "whose final return to his University formed a tragic ending to the sentimental journey of his life."

Professor Haviland made the first collection of anatomical specimens, while the first museum was founded by his successor Professor Clark, who raised it to be the first in the world. We have entered upon a goodly heritage, and, in the stimulating presence of Sir George Paget and Sir George Humphry, may we not learn to penetrate yet farther into those regions of knowledge where the unknown still far exceeds the known?

ARTIFICIAL COLD.

By VAUGHAN CORNISH, B.Sc., F.C.S.

WITHIN the last twelve years the production of artificial cold has become an important industry. The principle of the methods employed has long been known, but it is only recently that the great practical difficulties of the problem have been overcome. The requisite impulse was given by the need of finding means for preserving meat in a fresh condition during its passage from foreign countries. For such purposes as this the freezing machines of Carré, which still figure in the ordinary text-books on Physics, are wholly inadequate. The problem was first practically solved by Coleman by the construction of the Bell-Coleman air machine, an apparatus so well thought out and perfected that in its first trial a cargo of meat of a value of £8,000 was transported across the Atlantic in a perfectly fresh condition. From 1879 the industry of

refrigeration has rapidly increased in importance as new applications have been perceived, and as further improvements in machinery have been effected. The subject has engaged the attention of many able engineers, and some three hundred patents have been taken out in connection with it. At the present time the production of low temperatures plays an important part, not only in the meat trade, but for the preservation of other perishable articles of food, as fish, eggs, and butter, in the brewing industry, and in the production of ice. New applications are being found every day, among which may be instanced the preparation of preserved fruits and similar processes, where crystallization from solution has to be effected. The important problem of the cooling of theatres is engaging attention at the present time, and will no doubt soon receive a satisfactory solution.

The principles involved in refrigeration present many interesting features which are scarcely touched upon in the ordinary works on heat. For the production of *high* temperatures it is usual to employ the force of chemical affinity; chemical combination in the process of combustion being attended with an evolution of heat. On the other hand, many chemical compounds are formed with *absorption* of heat; but these can only be produced in an indirect manner, and their formation cannot be employed for the production of low temperatures.

It is a curious circumstance that in order to understand the *rationale* of the refrigerating process it is necessary to consider, in the first place, the means of attaining high temperatures and the working of heat engines. By the burning of fuel in the furnace steam is produced in the boiler of a steam-engine, and by the changes of volume of the *working substance* (steam) a portion of the energy of heat is transformed into mechanical power. In other words, the energy which formerly consisted in that motion of minute particles which constitutes heat, is in the steam-engine converted into the form of energy which consists in the motion of a large mass of matter (*e.g.* of the piston or the fly-wheel of the engine). Briefly, in heat engines, of which steam-engines form one class, a calorific effect is converted into mechanical power. In refrigerating machinery, on the other hand, mechanical power is so employed as to yield a calorific effect; but in this case the calorific effect is *negative*, and the final result is the production of a *low* temperature. The refrigerating machine is not in itself a complete apparatus, since it requires to be *driven* by a steam-engine. In order, therefore, to attain logical precision in our view of the process of the artificial production of cold, it is necessary to consider as one complete system the combination of the steam-engine and the freezing machine. In this dual arrangement we start with the production of a high temperature in a furnace, and finally attain a very low temperature in the freezing chamber.

The working parts of the freezing machine are very similar to those of the steam-engine. In both there is a system of cylinders, pistons, and valves, and a working substance which undergoes alternately compression and expansion. In the Bell-Coleman machines the working substance is air. The process begins with the compression of air by the stroke of a piston in the *compression cylinder*. The power which drives this piston is obtained directly from the piston of the steam-engine. The compression cylinder is surrounded by a jacket in which cold water constantly circulates. The heat generated by the compression of the air is almost entirely taken up by the cold water. Thus we obtain air very little above the ordinary temperature, but under a high pressure. When the pressure is released the air expands. If the expansion be allowed to take place into a vacuum, then—as Joule first proved—no change of temperature takes place. But if the expansion takes place under such conditions that mechanical power is developed, the mechanical work is done at the expense of the heat of the expanding air, which consequently is chilled. This is what actually takes place in the *expansion cylinder*. The air, in expanding drives a piston which is connected with the cylinder of the steam-engine in such a way that it aids the back stroke of the piston in the steam cylinder. Thus the frigorific effect is obtained in the refrigerating machine by an action which lightens the work of the driving engine. By means of this expansion the air is readily cooled to -50° Fahr., or, if desired, to a still lower temperature. It was here that a great practical difficulty came in. Atmospheric air contains water-vapour, and at such low temperatures this was deposited in the form of hoar-frost. This frost or snow choked the valves and otherwise hindered the working of the machine. It was not found practicable to remove the moisture entirely before the admission of the air to the machine; and till the invention of Mr. Coleman the snow difficulty appeared to condemn the use of air as the working substance. This difficulty was overcome by the device of allowing a partial expansion of the air before it entered the expansion cylinder. This preliminary partial expansion is effected in sloping tubes placed in the refrigerating chamber itself. Under these conditions, the aqueous vapour deposits not as snow but in a mist or rain, and the moisture is run off by suitable taps placed at the bottom of the sloping tubes. The air thus freed from moisture enters the expansion cylinder to undergo the second and greater expansion by which the principal part of the frigorific effect is obtained.

The *cold air* freezing machines are those employed on board ship for the transport of meat from Australia, New Zealand, and America The meat is placed in large chambers, the walls of which are double, the interspace being filled with wood charcoal as a non-conducting material. A jet of intensely cold air is delivered into the chamber at each stroke of the piston of the expansion cylinder, and the temperature of the chamber is thus kept at or near the freezing point during the whole voyage.

There is another important class of freezing machines, of which the ammonia machines are the most important type. In this second class the working substance is not a permanent gas such as air, but a substance (such as ammonia) capable of being condensed to a liquid by pressure, even at the ordinary temperature of the atmosphere. In these machines the frigorific effect is due in the first place to the heat absorbed by the vaporization of the liquefied substance; and secondly, as in the air machines, to expansion of the vapour. Volume for volume, the working substance exercises a much greater cooling effect in the ammonia machines than in the air machines. Consequently the machinery is more compact and more economical of fuel. An important point of difference between these two types is that whereas the air machines work with an *open cycle*, drawing in a fresh supply of material at each stroke of the piston, the ammonia machines work in *closed cycle*, the same working material going through the same round of changes over and over again. It will readily be perceived that this circumstance necessitates very different arrangements in the freezing chamber to those which have been described above, where the working substance itself is delivered from the machine and is the direct cooling agent. The refrigerating chamber connected with an ammonia machine is generally cooled by the circulation of a cold liquid in pipes, on a system similar to that employed in heating by means of

hot-water pipes. The liquid is some solution having a very low freezing-point, such as a solution of calcium chloride in water, *brine* being the term generally applied to such solutions.

In the ammonia machines a special cylinder for expansion is not required, the expansion being allowed to take place in long coils of tubing, which are placed in a bath in which the brine is kept circulating. From this bath the cold brine is driven by pumps through the system of tubes. An important advantage possessed by the ammonia machines is the fact that there is no moisture to be removed, and their construction is in consequence considerably simplified. Except on board ship they have undoubtedly an advantage over the air machines, and are coming daily into more general use. For marine *installations*—to use the trade term—the air machines are still preferred, owing principally to the fact that in case of accident the working substance could not be removed in the case of ammonia, the escape of which, owing to an accident in rough weather, would, moreover, be highly inconvenient.

An interesting application of cooling by means of brine has lately been made in mines. One of the greatest difficulties which can occur in the operation of sinking a shaft is that presented by a stratum of sand saturated with water. In more than one case this difficulty has been overcome by freezing the sand and water into a firm mass and then continuing the sinking operations as if the material were solid rock. The shaft having been sunk to the upper surface of the quicksand, a number of small bore-holes are made to the bottom of the stratum, and in these are placed tubes closed at the bottom, through which cold brine is circulated from a tank at the surface, which is cooled by an ammonia machine. In the course of a few days the quicksand is frozen to a solid mass, and the boring can be proceeded with. It will thus be seen that the production of artificial cold is an industry which, though still in its infancy, has already attained considerable importance. It appears likely that the next ten years may see a development scarcely less rapid than that of the last decade.

Whist Column.

By W. Montagu Gattie, B.A.Oxon.

The following is an elementary explanation of the play of the hand published in the February number of Knowledge. For convenience of reference, the distribution of the cards is here repeated.

	Z	
	D.—Kg., 5, 3, 2. C.—9, 8, 2, H.—10, 7, 4, 2. S.—10, 8.	
B D.—8, 7, 4. C.—Ace, 6, 5, 3. H.—Kn., 9, 6, 5. S.—6, 2.	Z turns up the King of Diamonds.	A D.—Ace, Qn., 9. C.—Qn., Kn., 7, 4. H.—Kg., 8, 3. S.—Kg., Qn., 5.
	D.—Kn., 10, 6, C.—Kg., 10. H.—Ace, Qn. S.—Ace, Kn., 9, 7, 4, 3.	
	Y	

Trick 1.—A opens his longest suit, and, having four only, leads the lowest; Y, holding king and another, passes the trick; B plays his highest card, and Z his lowest.

Trick 2.—B, by opening with a small heart, shows his partner four at least of that suit. He might return a club; but this would not be quite prudent, and would also be likely to mislead A, inasmuch as the immediate return of a partner's suit is usually interpreted as a request for a third round on which to make a small trump. Z plays his lowest heart, and A his highest; and Y of course wins the trick with his ace.

Trick 3.—Guided by considerations which have been explained already, Y leads a trump, and, having three only, opens with the highest, so as to assist his partner (who has turned up the king) as much as possible. Z gathers that Y has not more than three trumps; for he would not lead knave from a long suit unless he held the four honours, or king, queen, knave, and two others, and both these cases are precluded by Z's holding the king. Z therefore *finesses* the knave, and at the same time takes occasion to commence an "echo" to the trump lead by playing the three instead of the deuce. When the deuce falls at trick 5, four trumps at least are marked in Z's hand.

Trick 4.—A continues with the queen of clubs in order to clear the suit. He knows that (unless the ten of clubs was the beginning of a call for trumps) Y has either the king single or no more; but in the latter case Y would pass a small card led (for, B having played ace on the first round, the king must then be with Z), and Z might win with a small card, retaining the command of the suit. B's three of clubs shows that A led from four cards originally; for, the deuce having fallen already, the four must have been A's lowest club, and, with five of the suit, he would have led the lowest but one. Z plays his lowest card, and, as this is the eight, it follows that the only other club he can hold is the nine (the knave, of course, being marked in A's hand).

Trick 5.—Y continues with his next best trump, Z completes his "echo," and the ten draws the ace from A.

Trick 6.—A is reluctant to enable Y to make a small trump on the clubs, and therefore returns the hearts. Holding two only, he returns the higher, and, as B and Z play six and four respectively, Y concludes that the three is in A's hand. He notices also that B, who led the five at trick 2, now plays the six, and therefore can only have had four hearts originally; so that, as A can have but one (the three), Z must hold the other two.

Trick 7.—After this third round of trumps, Y counts the hands, from inferences already drawn, thus:—Z's "echo" at tricks 3 and 5 has shown that he has the long trump; he has two hearts, from trick 6; and not more than one club, from trick 4. Therefore he must have at least two spades. A has the knave of clubs and one other (tricks 1 and 4), and the three of hearts; therefore he must have three spades. There remain for B two hearts, and either two clubs and two spades, or three clubs and one spade, according as Z has the nine of clubs or not.

Trick 8.—Z's proper lead is obvious enough. It would be fatal to lead up to Y's tenace in hearts, and he cannot do better than give his partner the best spade he has. A, holding king, queen, naturally puts on the queen to draw the ace and make his king good; but, looking at the great strength in spades declared in Y's hand, it would probably be better play to pass the ten, and that course would certainly save the game, whether Y *finessed* or not. A's play, however, is quite orthodox. Y's *coup* has already been fully explained. Its merit consists in his seeing that, except in the improbable case of Z's holding the best and

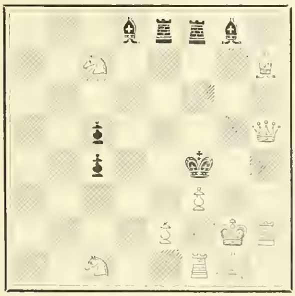
second-best hearts, the game cannot be won, and may be lost, if Z has the lead after becoming exhausted in spades. It should also be noticed that, while B and Z know perfectly well how the hearts are divided, A and Y are in the dark on this point. It is this uncertainty which deters A from leading a heart at trick 10, although he would thereby not only save but win the game, if B should be found with the best and second-best hearts. The maxim "Simplify the game as much as possible for your partner," has a scarcely less important correlative, "Place your opponent, whenever possible, in a difficulty." Y achieves both purposes in this instance by foregoing a single trick.

Chess Column.

By C. D. Locock, B.A.Oxon.

Problem by T. Taverner.

Black (7 pieces).



White (10 pieces).

White to play, and mate in two moves.

The above beautiful problem is taken from the *Liverpool Weekly Mercury*.

For the benefit of any who may find it too difficult, the following puzzle is given as an easier task.

Intending solvers need not be dismayed by its length: it is only necessary to go straight ahead. There are no variations, all Black's moves being forced.

Dedicated to Wordsworth Donisthorpe, Champion Stale-mater of the World.

Black (12 pieces).

White (10 pieces).

White to play, and *stale-mate his own King* in fifteen moves.

CHESS FALLACIES.

I. (Legal) That it is unlawful for a player to Castle on the Queen's side when his QR square and QKt square are commanded by opposing pieces. This is a delusion under which many fairly experienced players are known to labour. The law merely says that the *King* in castling must not do so from, over, or into check.

II. That a Rook and Knight are stronger than two Bishops. Many games have been lost through this fallacy. If the position is an open one with Queens on the board, the two Bishops if favourably posted will often win.

III. That the Queen is worth two Rooks and a Pawn. On the contrary, it can be proved that, when there are no other pieces on the board, two Rooks are nearly worth a Queen and Pawn. For, provided the K be secure from perpetual check, the two Rooks can double to attack the weakest Pawn, which can only be defended by the King and Queen. The two Rooks can then be exchanged for the Queen and Pawn.

IV. That P to R3 is a harmless "waiting" move. As a matter of fact, there is no such thing as a harmless waiting move in the earlier part of the game. The move P to KR3 is doubly disadvantageous In the first place, the Pawn becomes a mark for the opponent's Queen's Bishop. And secondly, it makes it inadvisable afterwards to move the KBP, on account of the "hole" created at KKt3

V. The disadvantage of P to QR3 is a somewhat subtle one. Suppose, for example, the moves 1. P to K4, P to K4; 2. Kt to KB3, Kt to QB3; 3. B to B4, B to B4; 4. P to B3, Kt to B3; 5. P to Q3. Black now makes the "waiting" move P to QR3? White replies 6. B to K3. In positions of this sort, if the QRP were unmoved, Black would now retire the Bishop to Kt3. For if White exchanges, Black gets an open Rook's file. But in the present case, if he play B to Kt3, White exchanges with advantage. Or if he retire to R2, White gains two moves by taking it, leaving either the Kt or the R out of play. Black, therefore, is compelled either to exchange, and present White with an open KB file for his KR, or to play P to Q3, leaving White to exchange when it suits him.

CHESS INTELLIGENCE.

The Steinitz-Gunsberg match ended in a victory for Steinitz by 6 games to 4, with no less than 9 draws. The large proportion of drawn games seems to indicate a harder fight than the Steinitz-Tschigorin match of 1889, which the former won by 10 games to 6, with only 2 draws. On the whole, however, the result of the match is a confirmation of previous form, as shown in the recent drawn match between Tschigorin and Gunsberg. It is possible that Mr. Steinitz might have won both matches, had he chosen, by a somewhat larger majority. His invariable habit of adopting unsound defences undoubtedly caused the loss of several games in both matches. At the same time, it should be remembered that the intrinsic badness of his novelties is to a certain extent balanced by his greater familiarity with them. For these novelties are not played on the spur of the moment. On the contrary, they have generally been in Mr. Steinitz's note-book for many months before the match begins.

The Steinitz-Tschigorin Correspondence games have now been resumed.

The following moves have been made since the publication of the Diagram in the January number:—

"Evans Gambit."

White (Tschigorin).	Black (Steinitz).
18. B to R3	P to QB4
19. QR to Qsq	Kt to B3
20. B to B4	B to B2
21. Kt to Q5	

Present Position.

Black.

White.

"TWO KNIGHTS' DEFENCE."

WHITE (Steinitz).	BLACK (Tschigorin).
19. B to Kt2	P to B 5
20. Q to B2	Q×P
21. K to Bsq	P to B6

Present Position.

BLACK.

WHITE.

Mr. Gunsberg is expected to return before the end of February, but not in time to edit the Chess Column for March.

There are rumours of a match between Mr. Steinitz and Dr. Tarrasch of Nuremberg, who won the last two International Tournaments without losing a single game in either. The German amateur has signified his willingness to play; but it takes two to make a match, and Mr. Steinitz's consent is not always easy to obtain. Considerable self-denial in the matter of terms is essential on the part of anyone who wishes to be his opponent.

The match would be interesting as a contest between master and pupil; for Dr. Tarrasch is an exponent of that "modern school" of which Mr. Steinitz claims to be the founder. On that very account it is probable that, *if* the younger player should lose the match, he would be defeated by a more decisive majority of games than players of the opposite school, such as Tschigorin and Gunsberg, who attack Mr. Steinitz sometimes in a style of which he strongly disapproves, instead of waiting to be slowly attacked themselves, in accordance with Mr. Steinitz's principles.

The following game, played in the Manchester International Tournament of last year, is given, for want of a better, as a specimen of Dr. Tarrasch's style.

"RUY LOPEZ."

WHITE (C. D. Locock).	BLACK (Dr. Tarrasch).
1. P to K4	1. P to K4
2. Kt to KB3	2. Kt to QB3
3. B to Kt5	3. P to QR3
4. B to R4	4. P to QKt4 (*a*)
5. B to Kt3	5. B to Kt2
6. P to Q4	6. P×P (*b*)
7. Castles (*c*)	7. P to KKt3 (*d*)
8. Kt×P	8. Kt to R4 (*e*)
9. P to QB3	9. Kt×B
10. P×Kt	10. B to Kt2
11. R to Ksq (*f*)	11. Kt to K2
12. P to QKt4! (*g*)	12. P to Q3
13. Kt to Kt3 (*h*)	13. Kt to B3
14. QKt to Q2	14. Castles
15. Kt to B3	15. Q to Bsq (*i*)
16. Kt to R4 (*j*)	16. Q to K3
17. P to KB4	17. KR to Ksq
18. B to Q2 (*k*)	18. Q to B5!
19. B to K3 (*l*)	19. Q×KP
20. Kt to Q2	20. Q to K2
21. Q to Kt4	21. P to KB4
22. Q to R3 (*m*)	22. B to B3
23. Kt (Q2) to B3	23. Q to Kt2
24. QR to Qsq	24. P to QR4 (*n*)
25. P×P	25. Kt×P
26. Q to Kt3	26. Kt to B5
27. B to Bsq	27. B to K5!
28. Kt to Q4	28. P to Kt5!
29. Kt (R4) to B3	29. P×P
30. P×P	30. P to B4
31. Kt to K2 (*o*)	31. B to B7
32. R to Q5	32. Q to B2
33. Resigns	

Notes.

(*a*) An obsolete and not very satisfactory defence, revived probably with the view of getting "out of the books."

(*b*) Best. Mr. Steinitz recommends here 6. . . . Kt×P, overlooking the winning reply 7. B×P ch! K×B; 8. Kt×Pch, K to K3; 9. Q×Kt, P to B4; 10. Q to B3, and if 10. . . . P to Kt5, 11. Q to KKt3, with a strong attack whether Black take the KP or not. If, for instance, 11. . . . B to Q3, White wins by Q to Kt4 ch!

(*c*) Better than retaking the Pawn immediately.

(*d*) The result of twenty minutes' consideration, and very likely therefore the best move. If 7. . . . Kt to B3, 8. PK5; while 7. . . . B to B4 (or B to K2) would be met by 8. P to QB3 with the advantage.

(*e*) Dr. Tarrasch afterwards thought that 8. . . . B to Kt2 at once would be better. White's reply would have been P to QB3, providing a loop-hole for the escape of his Bishop.

(*f*) To prevent PQ4.

(*g*) The best move, creating two "holes" at Black's QR4 and QB4, which he will be able to command still further by a Knight at QKt3.

(*h*) White now proceeds to do in four moves what he could do perhaps equally well in two. He might play the other Knight to Q2 and Kt3. For after 13. QKt to Q2, B×Kt; 14. P×B, Kt to B3; 15. Kt to Kt3, Kt×P; 16. Kt to R5, followed by P to Q5, threatening to win a piece by Q to Q4, the position is probably worth the Pawn, and with Bishops of opposite colours there should be no danger of losing.

(*i*) Black's development is still difficult. If 15. . . . Q to Q2, White might reply 16. Kt to B5.

(*j*) To prevent P to KB4. Dr. Tarrasch thought that White could have maintained his advantage by 16. KKt to Q4, Kt×Kt; 17. P×Kt, considering the open QB file more than an equivalent for the isolated Pawns. Black, however, has two Bishops, and might continue with P to KB4.

(*k*) A bad move, of which Black takes immediate advantage. Kt to KB3 would be better. For if then 19. . . . Q to B5, 20. Kt (Kt3) to Q2, and the Q cannot play to Q6, on account of the reply K to B2.

(*l*) Having no way of saving the Pawn (Q to B2 would lose the QKtP) White compels his opponent to take it with the Queen.

(*m*) Q to Kt3 would be better, so as to be able to play P to KR4.

(*n*) Having secured himself from all attack, Black now proceeds to finish off the game in the most expeditious manner.

(*o*) The only move not to lose the Knight.

CONTENTS OF No. 64.

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CONTENTS.

A SEED, AND WHAT IT CONTAINS.

By J. PENTLAND SMITH, M.A., B.Sc., &c., *Lecturer on Botany, &c., Horticultural College, Swanley.*

A SEED has from time immemorial been taken as the symbol of reproductive power. To explain adequately what are the significations of its different parts, we must first occupy ourselves with a preliminary developmental sketch, and will commence with a description of the method of reproduction of *Aspidium filix mas*, the Male Shield Fern, one of that large group of plants called Vascular Cryptogams. Its life-history has previously been discussed in this Magazine. At present we will only touch on those parts of its structure which immediately concern us.

Brown patches may at times be noticed on the backs of its leaves. These are collections of spore-bearing sacs, or sporangia, that are covered over by a growth of the leaf termed the indusium (Fig. I. *a.*). The contained spores are all alike. They are minute single-celled bodies filled with protoplasm and nourishing material. The sporangia rupture when ripe, and the spores fall to the ground. There they germinate if the conditions are favourable, and the product of germination is a small green plate of tissue, about one-sixteenth of an inch in length and breadth, and shaped as seen in the diagram (Fig. I. *b.*). It is called the prothallus. On its under surface are two kinds of organs, which are of great importance in the life-history of this fern. These are the archegonia (Fig. I. *b.*, *arch.*, and *d.*), or female organs, and the antheridia, or male organs (Fig. I. *b.*, *an.*, and *c.*). The archegonia are flask-shaped. The base of the flask, which is embedded in the prothallus, contains an egg or *ovum*, the female reproductive cell. The anthe-

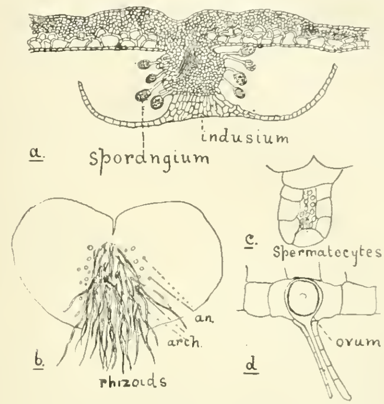


FIG. I.—*a.* Transverse section of leaf of a Fern (*Aspidium filix mas*), showing sporangia. *b.* Under surface of prothallus; *arch.*, archegonia; *an.*, antheridia. *c.* Longitudinal section of antheridium (much magnified). *d.* Ditto of archegonium.

ridia are globular in form. Each one contains numerous lively specks of protoplasm (*πρωτος* first, and *πλασμα* form, the living part of the plant-cell, by whose activity the plant is built up), which move about with great agility when the antheridia burst. They then make their way (if moisture be present) to the neck of the archegonium; one of them enters it, and pierces the ovum. Thus impregnation is effected.*

The result of fertilization is a fern-plant that during its early period of existence sends out an organ called a foot into the tissue of the prothallus, to absorb therefrom the food-material that the plant is as yet unable to obtain independently for itself. In the meantime it sends roots into the soil and a stem into the air, and when the prothallus is exhausted, it is ready to commence life on its own account.

In *Equisetum*, the Horse-tail, an ally of the fern, the processes are essentially similar, but the male and female organs (the antheridia and archegonia) are borne on separate prothalli, although the spores from which these arise are all alike.

In a higher branch of Vascular Cryptogams differentiation of male and female is carried back a further stage, for two kinds of spores are here produced. *Selaginella*, so common in our greenhouses, may be selected as a typical

* Prothalli are often found growing in the crannies of the wall of a greenhouse in which ferns have been standing, but the non-possessors of a greenhouse can easily procure prothalli by sowing spores in a pot of light soil, carefully watering them, and covering the pot with a bell-jar. The length of time the spores take to germinate depends on the species of fern from which they have been derived. Suppose that a prothallus has been found, that the little root-hairs on the under surface have been freed from particles of soil by careful manipulation under water with a camel-hair brush, and that it has been mounted in water on a glass slide, under-side uppermost, and covered with a cover-slip. It is now ready for examination under the high power of a microscope. By gentle pressure of the cover-slip the spermatozoids may be ejected from the antheridia, and may be seen wriggling through the water.

example. The male spores are much smaller than the female; hence their respective names, microspores and macrospores (μικρος small, μακρος large). The sporangia which contain these are termed microsporangia and macrosporangia respectively (Fig. II. *a.*). When the macrospore (*ma. sp.*) germinates, the prothallus does not come out of the spore, but remains as a mass of tissue, *without* green colouring-matter inside it, and in addition there is a nourishing material called endosperm, which later on becomes divided up to form a tissue of cells (Fig. II. *b.*). The male prothallus also remains inside the microspore. It consists of only one cell, and has no chlorophyll. A peculiar organ, termed the suspensor, develops from the fertilised egg, as well as the true embryo plant. It pushes the embryo into the endosperm.

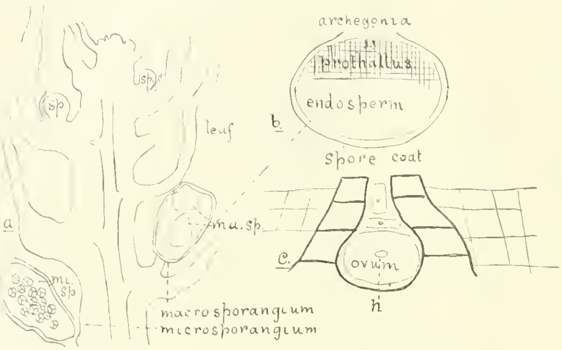


FIG. II.—*a.* Longitudinal section of apex of sporangium bearing shoot of *Selaginella*; *sp.*, developing sporangia; *mi sp.*, microspores; *ma.sp.*, macrospores. *b.* Diagrammatic section of germinating macrospore. *c.* Ditto of archegonium (much magnified.)

so that it may feed on it. It is noteworthy that the growth of the embryo takes place *inside* the spore, not outside, as in the two former cases.

The cone of *Pinus* (e.g. *Pinus sylvestris*, the Scots Fir), is a collection of leaves that have become modified to bear ovules, which afterwards are termed seeds. The ovule is a macrosporangium which, however, differs from that of Selaginella in that it possesses a covering or integument (Fig. III. *b.*, *in.*). The whole of the interior of the ovule is occupied by the prothallus. The male spore is familiarly spoken of as the pollen-grain, and the microsporangia as the anther-lobes or pollen-sacs; they are borne on the under surface of the stamens (Fig. III. *a.*, *st.*, *p.*) The pollen-grain is provided with two bladders or floats, and is carried by the wind to the ovules which lie exposed on the upper surface of the carpels or modified leaves on which they arise. The integument does not quite enclose the ovule, but leaves a small aperture, the micropyle (μικρος small, and πυλη a gate) for the reception of the pollen-grain. There the microspore (pollen-grain) enters and rests on the surface of the macrosporangium, germinates, and sends a tube (Fig. III. *c. d.*, *f.*; and *b.*, *p.*) into the microspore, where it comes into contact with the ovum, in one of the archegonia developed in the prothallus.

There is no endosperm in Pinus, as in Selaginella, but the important points to be noted are that not only does the embryo develop inside the macrospore, but the macrospore remains inside the macrosporangium that is still attached to the parent plant, from which it derives sustenance; for after the developing embryo has used up all the nourishment in the prothallus, fresh nutriment is poured into the macrospore from that source.

When the tube of the pollen-grain, which we may compare to an antheridium, touches an ovum in one of the archegonia, it sends part, at least, of its contents into it. As a result the ovum divides up to form a young plant (Fig. III. *e.*), that is provided with a long suspensor. The embryo is so placed that its root lies towards the micropyle. The mature ovule (macrosporangium) with its coat is the *seed*, and the collection of seed-bearing leaves which we find form what is commonly called a flower.

The Angiosperms (ἀγγειον a vessel, and σπερμα a seed) are so called from the fact that their seeds are enclosed by the leaves (carpels) on which they are borne; and in this they differ markedly from the Gymnosperms (γυμνος naked), such as the Pine, in which these are quite exposed. The majority of our familiar garden shrubs and forest trees belong to the large group of Angiosperms. A carpel may bear one or many ovules, which later on develop into seeds, and the carpel itself undergoes, as a rule, a characteristic change to form what we know as the fruit. The pollen-grains are found in sacs (anther-lobes or pollen-sacs)* situated on the upper portions of the stamens.

They are very similar to those of the Pine; but instead of having balloons they often possess warts or prominences by means of which they may adhere to the various animals that carry them to the stigmas of the carpels on which they must alight in order that they may be in a position to accomplish their *rôle* in life.

We have reserved until this stage a minute examination of the macrosporangium, or ovule—the organ that is of such vital importance in connection with the reproduction of the plant; the reason being that it is best to take for this purpose familiar examples such as may be easily procured by anyone desirous of making the examination of

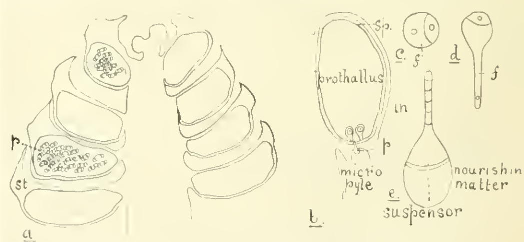


FIG. III.—*a.* Diagrammatic longitudinal section of male cone of *Pinus* (Scots Fir) Only two of the pollen-sacs are represented containing pollen-grains (microspores), *p.*; *st.*, stamen, with pollen-sac on under surface. *b.* Ditto of *ovule* of Pinus; *p.*, pollen-grain germination; *m.*, micropyle; *in.*, integument (coat) of macrosporangium (ovule); *sp.*, wall of macrosporangium. *c.* Pollen-grain; *f.*, cell which will develop into pollen-tube *d.* The same, with cell (*f*) developed as pollen-tube. *e.* Diagrammatic representation of developing egg; there ought, in reality, to be four embryos figured arising from these ovules.

the object for himself. These are best found in the buttercups and daisies, the hyacinths and lilies of our fields, woods, and waysides. In all these cases the ovule is contained within the carpel or carpels, and the pollen-grain

* See article on "Some Curious Modifications to Prevent Self-fertilization."—KNOWLEDGE, Feb. 1891.

can only effect an entrance to it by way of a tube (in many cases) in the style which opens to the exterior, in the stigma, and communicates below with the cavity of the ovary or ovule-containing portion of the carpel. The ovule is built up on the same plan as that of the Pine, but instead of being furnished with one integument, it has two, both of which completely enclose it with the exception of an aperture, the micropyle, so that the pollen-tube may be enabled to reach the macrospore. Fig. IV. *a.* shows a vertical section of an ovule of the Hyacinth (*Scilla nutans*) as it appears before fertilization; on the outside are seen the integuments, enclosing the wall of the macrosporangium. The part by which it is attached to the carpel is called the stalk, or funiculus (*f.*); *m.* is the micropyle. The macrospore is known as the embryo-sac; towards its micropyle end lie the ovum (*ov.*) and two cells, synergidæ, (*syn.*; συν with, and ἔργον work), which are thought to represent an archegonium, as they guide the pollen-tube to the ovum. At the opposite end there are three cells (*ant.*), termed the antipodal cells. They represent the prothallus which filled the whole embryo-sac in Pinus, and was an independent plate of green tissue in the Fern. It is, then, very much reduced here. This is the tendency in plants: the higher the plant, the greater the reduction of

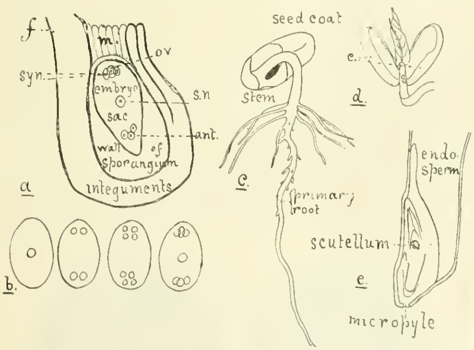


Fig. IV.—*a.* Diagrammatic section of ovule of *Scilla nutans* (Wild Hyacinth) previous to fertilization; *m.*, micropyle; *f.*, funiculus (stalk); *ov.*, ovum; *syn.*, synergidæ; *ant.*, antipodal cells; *sn*, secondary nucleus. *b.* Diagram illustrating development of embryo-sac (macrospore). *c.* Germinating Bean (*ad. nat.*). *d.* The same at a slightly later stage; *c.*, cotyledons; *s.*, young stem bearing ordinary leaves (*ad. nat.*). *e.* Diagrammatic section of portion of seed of Grass.

the prothallus stage of its growth. The central cell is the secondary nucleus. The remainder of the macrospore is filled with nourishing material.

It will be interesting to note how these cells have originated. We will go back to that stage in which the embryo-sac (macrospore) appeared as a single cell, when it was essentially the same as the Fern spore. All cells contain a nucleus, which is probably a part of its protoplasm that has become denser in structure, and perhaps changed in some other way. The nucleus is an important body, as in the division of cells it first divides up, and then becomes surrounded with protoplasm. The nucleus of the embryo-sac divides into two. The two thus formed similarly divide, and so do the resulting four nuclei. The positions they assume in each stage are shown in Fig. IV. *b.* Then one nucleus from each end of the macrospore travels to the centre. There they fuse to form the secondary nucleus. This stage is represented in the fourth diagram of Fig. IV. *b.*

The pollen-grain, when it has alighted on the stigma, commences to germinate, and sends a tube down the style, just as that of Pinus does; only here germination takes place on the stigma, whereas in Pinus it is effected on the macrosporangium (ovule) itself. The contents of the tube having fused with the egg, the latter divides up to form the embryo. At the same time the secondary nucleus splits up, and so on until the whole of the embryo-sac is filled with a tissue—endosperm, a mass of nourishing material. The developing embryo is furnished with a suspensor, as was that of Selaginella and Pinus, and, as in the latter case, development takes place in such a way that the root is directed towards the micropyle, and the first leaf or leaves, as the case may be, in the opposite direction. The reason of this arrangement will soon be obvious. All plants containing green colouring-matter (chlorophyll) obtain a large proportion of their food (at least the whole of their carbon) from the air. But when chlorophyll is absent the process of carbon assimilation, that is, the breaking up of the carbon dioxide of the air and taking up of the carbon and part of the oxygen, cannot go on, so the plant starves. This anyone can test for himself by growing plants in the dark; then chlorophyll will not be formed, what was previously there will disappear, the plant will assume a miserable, starved appearance, and will soon die, unless again brought to the light. However, place a potato in a dark, moist cellar (most cellars appear to possess these qualifications), and see what happens. A long, lanky plant will be produced. This will appear to contradict the statement just made; but a little consideration will show that it only apparently does so, for the potato is a storehouse of nutritive material on which the developing plant has been feeding. Whenever this store is exhausted, the plant dies. The ovule partakes in a great measure of the characteristics ascribed to the potato tuber. It is a reservoir of nourishing matter, in which the young plant is bathed at the commencement of its existence; this material it absorbs before it quits the seed.

For the examination of a mature seed we will take the common Garden Bean. It shows outside a scar or *hilum* that indicates the position of the short stalk which joined it to the carpel, and near the hilum is a small opening, the micropyle. Take a penknife and cut the seed-coat, and the contents will then fall out, and probably divide into two thick fleshy lobes, on one of which there is a knob-like process. This small process is the young plant, and the two fleshy lobes (Fig. II. *d.*, *c.*) are its seed-leaves or cotyledons, as they are ridiculously termed. However, this term must be remembered, as it is used in the naming of two large groups of Angiospermous plants—the Monocotyledons and Dicotyledons. The Monocotyledons (μονος one) have only one seed-leaf. Examples of these are found in the Lilies, Hyacinths, Irises, and Crocuses. They are further distinguished by the possession of leaves which have their veins running in a parallel manner. The Dicotyledons (δις twice), on the other hand, have two seed-leaves, and their leaves are net-veined. Our forest trees and many of our common garden plants afford us examples of these. The seed-coat is formed by the integuments and wall of the sporangium. The whole of the cavity of the macrospore, or embryo-sac, is occupied by the embryo plant and its enormously large cotyledons. The latter have absorbed the nourishing material that previously existed in the macrospore. A seed which, when mature, contains no nourishing matter is said to be *exalbuminous*.

We will compare this seed with that of a grass, such as the Wheat (Fig. IV. *e.*). A vertical section shows

that the young plant occupies only a small part of the embryo-sac; the rest is filled with nourishing material, to absorb which a part of the stem of the embryo assumes a shield-like shape—scutellum—and applies itself to it. This is an *albuminous* seed; but the shield is not developed in all seeds of this kind.

When a seed commences to germinate, water is absorbed, and a great quantity of oxygen is taken in. The chemical processes which go on, the limits of this paper will not allow us to discuss. Let it suffice to say that the root passes out by the micropyle, and fastens the plant firmly in the soil. In the meantime, if the plant be albuminous, the embryo is absorbing the nourishing material by means of its seed-leaves, and living on it; while if exalbuminous, as is that of the Bean, the food-material contained in the cotyledons is gradually used up, so that these organs soon lose their fleshy appearance. By this time the plant has obtained a firm hold of the soil, and then the seed-coat is thrown off, chlorophyll appears in the leaves, and the young plant is enabled to start life on its own account.

NUMMULITES AND MOUNTAINS.

By R. Lydekker.

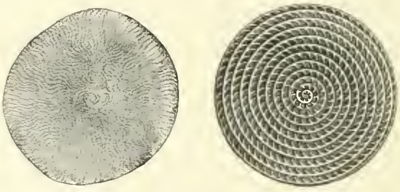
Both the proverb "as old as the hills," as well as the phrase the "everlasting hills," are but the expression of the natural tendency of the human mind to regard all hills and mountains as the most lasting and ancient objects with which we are familiar. As, however, is so often the case, science steps in and tells us that, although the proverb and the phrase are true enough as regards human experience, yet that when we go back and study the origin of things, as revealed by geology, we find that many hills and mountains—and more especially the highest of them—are actually among the very newest features in the physiognomy of the earth, and that the expression "as old as the plains" would, in many instances, be a far truer simile than the one current.

If, indeed, we reflect for a moment, we shall be convinced that the highest mountains of the globe—always excepting volcanoes, which have the power of renewing their height—must necessarily, as a general rule, be younger than many of those of lower height, or even than the plains from which they rise. Thus rain, snow, frost, and rivers are perpetually tending to wear down and wash away all the higher points of the earth's surface, and to carry the *débris* to the valleys below. Consequently, we are led to conclude that, *primâ facie*, the higher a mountain range is, the less time it has been subject to this washing-away process, and, therefore, the younger it is as regards relative age. It might, indeed, be objected to this that the mountains that are now the highest have always been the highest; and that at the beginning of all things their original height as much exceeded their present height as the latter does that of the smaller ranges. In this view, however, their original heights would have had to be so stupendous as to be almost inconceivable, and probably much greater than is compatible with the physical conditions of the globe. This hypothesis may, therefore, be dismissed as untenable; more especially as there is direct evidence of a totally different kind, which is conclusive as to the truth of the alternative view.

This evidence is afforded by fossils, and more especially by a particular kind of fossil, which, from its abundance and the restricted geological epoch in which it is found, is of more than usual value in inquiries of the present nature.

If any of our readers have ever examined the Tertiary clays and sands of Barton, in Hampshire, or of Bracklesham, on the Sussex coast, they will probably have met with numerous disc-like objects, the larger of which are somewhat more than an inch in diameter, while the smallest are scarcely bigger than a pin's head. When split or cut, these objects are found to contain a number of minute chambers, separated from one another by thin walls arranged in the form of a spiral, as shown in the figure. Technically they are known as nummulites, and belong to the very lowest division of the animal kingdom —lower even than the sponges, which some people cannot be persuaded to believe are animals at all. Now these nummulites are exceedingly interesting to those who study the growth and formation of mountain ranges, for the reason that they occur, in any quantity and of large size, only through the greater portion of the Eocene or lowest division of the Tertiary (latest) geological period, although not reaching down to the London Clay; and also because they were very widely distributed in the seas which then covered a large part of our existing continents. If, then, we should find rocks containing great numbers of large nummulites on the flanks or tops of a mountain range, we should be assured that such range was younger than the Eocene period, at which date its component rocks were being formed as mud at the bottom of the sea.

Now, although in England the aforesaid nummulites only occur in soft beds of clay and sand in the low cliffs of the southern coast, when we cross to the Continent we find them forming the greater part of a massive limestone, known as the Nummulitic Limestone. This very characteristic rock is more massive and more widely spread than any other Tertiary deposit, and, in its thickness and



A Nummulite, viewed from above, and Horizontally Bisected.

identity of structure over large areas, recalls the Mountain Limestone of the Palæozoic epoch. It is, indeed, absolutely one mass of nummulites, of which sections are displayed on every fractured surface; and it was probably an open sea deposit, which must have taken incalculable ages for its formation. It occurs in Southern Europe in both the Alps and Pyrenees, attaining a thickness of several thousand feet in the former, and occurring at elevations of more than 10,000 feet above the sea-level. In the Pyrenees it forms a beautiful white crystalline marble. On the south of the Mediterranean, Nummulitic Limestone is found again in the mountains of Algeria and Morocco. In Eastern Europe it reappears in the Carpathians, and thence may be traced into the Caucasus and Asia Minor. All travellers to India are familiar with the Mokattam range of bare mountains on the western shore of the upper part of the Red Sea, which are likewise almost entirely composed of this same limestone. It is, indeed, a common belief among the Egyptian peasantry

that the larger disc-like nummulites are lentils left by the builders of the pyramids, and subsequently turned into stone. From the Caucasus and Asia Minor the Nummulitic Limestone may be followed into Persia, Baluchistan, Sind, the Punjab, and so into the Himalaya. Thence it continues into Assam and Burma, and reappears in the Andaman and Nicobar Islands in the Bay of Bengal.

It is, however, in the inner Himalaya that the occurrence of Nummulitic Limestones and certain overlying Tertiary rocks is of more especial interest, since it is there that they attain a greater elevation than in any other part of the world. It is in the upper Indus Valley, in the neighbourhood of Leh in western Tibet, that these nummulitic rocks occur; running some distance down the Indus to the west of Leh, and to the eastward of that town extending into Chinese territory. There is good evidence to show that the arm of the sea in which these nummulitic rocks were deposited communicated with the ocean to the eastward in the Bay of Bengal, instead of following the course of the Indus in a westerly direction to the Arabian Sea. Moreover, in some parts of this area the rocks which overlie, and are, therefore, newer than the Nummulitic Limestone, are raised to the stupendous elevation of more than 21,000 feet above the sea-level.

We have, therefore, before us decisive evidence to show that those parts of the earth's surface which at the present day form some of the highest peaks in the Himalaya were, at the period when the London Clay was deposited, below the level of the sea; and consequently that the elevation of that part of the Himalaya has taken place entirely since that epoch, during a period when the physical features of England have altered only to a comparatively slight degree. There is, moreover, equally conclusive evidence to show that the elevation of the Himalaya was not completed until a much later epoch of the earth's history, since on the southern flanks of this mighty range we find beds of sandstone containing remains of mammals which lived during the Pliocene, or later Tertiary epoch, raised to a height of several thousand feet above the sea-level.

The elevation of the Indus Valley in the heart of the Himalaya could not, therefore, have commenced until the Miocene, or middle Tertiary epoch, while that of the outer Himalayan ranges could not have been completed till far into the Pliocene period, and, for all we know to the contrary, may still be in progress. Not only so, but the same evidence likewise tells that the Alps, Pyrenees, Carpathians, the Caucasus, and the Egyptian Mokattam range, as well as the mountains of Algeria, have all attained their present elevation since the latter part of the Eocene period, when at least a considerable portion of their area was submerged. And we accordingly learn that many of the most striking physical features of the Old World are of comparatively modern origin.

When, however, we turn to mountains like those of the Lake District and Wales, which only attain moderate elevations, and in which the rocks belong solely to the Palæozoic, or oldest geological epoch, it is evident that we have to do with elevations of an extremely remote date. There is, indeed, satisfactory proof that these old mountains were once vastly higher than they are at present; their diminished altitude being due to the long ages during which they have been subjected to the wear and tear of the elements. To such mountains the proverb to which we have already alluded is, therefore, strictly applicable; but in a geological sense the phrase "everlasting hills" can be applied neither to the oldest nor the youngest mountains.

DISSEMINATION OF SEEDS.

By Theodore W. Dicker.

THE dispersion of seeds over the wide surface of the globe, which has been of so much importance in the distribution of vegetable life, has been accomplished by adaptations as marvellous as they are effective. In these methods we find another proof of Nature's firm determination to carry on the race. First we have the astonishingly lavish manner in which seeds are produced. Eight thousand have been counted in a single capsule of the White Poppy, whilst it has been estimated that a single Tobacco-plant can produce 360,000. How multitudinous, too, are the microscopic spores of the Flowerless Plants. It has been calculated that a single frond of Spleenwort could produce a million spores, and it is necessary to only slightly kick a mature Puff-ball (Lycoperdon) to drive the spores out in a small cloud. Why, then, it may be asked, with all this tremendous reproductive potency, is not the earth overrun to a most inconvenient extent by plant-life? The possibility of over-production is checked in many ways, among which are the unsuitability of position, the destructive struggle for existence which goes on among crowded plants, and by the great consumption of seed by men and the lower animals.

In addition to the exuberance of production we must take into consideration the power which seeds and fruits possess of resisting injury. They are less perishable than any other part of the flowers producing them, and are well adapted to retain their vitality, even through great changes of temperature, for a length of time. Some wheat which Sir George Nares brought from the Arctic regions, where it had been left by the crew of the *Polaris* two years before, was found to still possess its germinating power; and Dr. Trimen states that some seeds of Nelumbium in the herbarium of Sir Hans Sloane, who died in 1753, germinated in 1866.

In the distribution of seeds we find three kinds of agencies concerned, sometimes acting independently and sometimes in concert. First, there are the remarkable efforts which plants themselves make to disseminate the products of fructification; secondly, there is the powerful instrumentality of two inanimate forces without, viz. wind and water; and, lastly, there is the unconscious but interested action of animal life.

Let us examine first the methods by which plants themselves seek to insure the proper disposal of their seed. Dissemination generally begins at the close of life in annual plants, and at the "period of rest" in woody plants. It is then, except in the case of succulent fruits, that the fruit attains the degree of dryness necessary for the liberation of the seed. Indeed, fruits may be roughly divided into dry and succulent. As succulent fruits generally exhibit no particular mechanical efforts in themselves at dissemination, it is with the former, or dry fruits, that this part of our article is concerned. Dry fruits, again, may be separated into the *dehiscent*, or those in which the pericarps, or seed-cases, open to permit of the escape of the contained seeds, such as the Pea-pod, and the *indehiscent*, or those in which the pericarps do not open. Taking first the *dehiscent* fruits, we find that they usually consist of a number of seeds enclosed in tough pericarps, as in the Poppy or the Vetch. As such fruits present no special attraction to animals, the seed-cases must of necessity open to permit of the exit of the seeds; for where the seeds are numerous it would manifestly be to their disadvantage if the fruit merely fell to the earth and they escaped only through the rotting of the seed-case, as this would

set up a struggle for existence in which only the most capable would survive. Fruits of this kind therefore split in a regular and distinctive fashion in order that the seeds may escape. And not only do the pericarps prevent a crowded planting by thus splitting, but they frequently still further carry out this important object by ejecting the seeds with considerable force. The methods by which this is achieved are most curious and interesting. The legume of the Pea splits along its two margins, the two halves falling away from each other and throwing off the seeds in various directions. The seed-cases of the Pansy and of the Violet explode, scattering the seeds forcibly. In the Gorse and the Broom a sudden burst of the pods and a spring-like twist of their two halves effectually disperse the contents. On sunny July days the cracking sounds produced by the bursting pericarps may be distinctly heard. The mature fruit of *Ecballium elaterium* separates from its stalk and ejects its seeds with great rapidity through the orifice left by the rupture. The sporangia of many ferns (Bracken) have an elastic ring which is probably intended for the energetic dispersal of the spores. In certain pines the scales of the cone, when thoroughly dried by the hot days of the summer following that of its production, open with a jerk, forcibly ejecting the winged seeds. Frequently a number will burst together, and then the sound may be heard at a great distance. In the expulsion of the seeds of the Balsam (*Impatiens*) the contact of some outside object is of advantage. The seed-case consists of one cell with five valves, and, if touched by accident when ripe, it at once bursts open, the valves coiling themselves violently, and, springing from the stalk, scatter the seeds in all directions. In the Poppy and the Snapdragon a still larger share of the work of releasing the seeds falls to an outer agency, for here the pericarp consists of a capsule which opens along the top by valves that leave small pores through which the seeds fall out when the capsules are shaken by the wind. In all of these various methods of the expulsion of seeds it would seem that they are due to mechanical causes, and depend in most instances (*Impatiens* excepted) upon a certain condition of dryness in themselves, and upon the state of the surrounding atmosphere.

Passing from the modes in which dry fruits, consisting of a number of seeds enveloped in tough pericarps, effect dissemination, we have to consider next the means which obtain among dry fruits whose seeds are not collectively enclosed in a strong seed-case. Here, too, we find the forcible ejection of seeds. Those of the Oat are scattered with such energy that on a fine, dry day the snapping thus caused is distinctly audible. But the most curious provision possessed by seeds of this class for self-dissemination is the hygroscopic awn. In the Wild Oat (*Avena fatua*), for example, there is attached to the glumella (a small leafy structure connected with the seed), a spiral awn covered with numerous fine hairs, and this awn has the power of expanding when moist, and of contracting when dry. Thus the attached seed is constantly on the move with the changes in the weather, the hairs clinging to any object met with, until germination or destruction puts an end to its motion. The seed of Barley, too, is provided with a similar awn, which is furnished with minute teeth that point towards its apex. The seed, when lying on the ground, naturally expands with the moisture of the night, and contracts with the dryness of the day; but, as the teeth prevent its moving towards the point of the awn, all motion must be in the direction of the base of the seed, which will thus travel many feet from the parent stalk. As a ready proof of this, an ear of Barley will, if placed seed uppermost in the coat-sleeve in the morning, be found to work up to the arm-pit during the day. A still more remarkable provision exists in Erodium, a genus belonging to the Geranium order, by which the seed buries itself. The fruit splits into five cone-shaped seeds, at the base of which is a long awn or filament. As the seed lies on the ground the awn remains straight so long as it keeps moist, but when it gets dry one side of the awn contracts, forcibly causing the upper end to form a curve which brings its point against the ground, and the apex of the conical seed downwards. The lower part of the awn now commences to contract into a spiral, causing the cone to rotate and to enter the earth where the hairs which it bears, and which point upwards, hold it fast. The spiral portion also enters the ground, forcing the seed downwards. Moisture now, instead of reversing the effect produced by dryness, only continues it, for the spiral coils, in trying to straighten themselves, are held fast by hairs, and the result is that the seed is driven deeper into the ground. It is a notable thing, as Mr. Francis Darwin has pointed out, that these burying contrivances are all of a similar nature, though belonging to plants of widely separated orders.

Having considered plants which possess special facilities in themselves for dissemination, we come to those which depend to a great extent upon outside agencies for their dispersion. Of these agencies, the all-pervading instrumentality of the wind may be taken as naturally next in order to the power of self-distribution. The exceeding smallness of many seeds, not to speak of spores, admits of their ready transport by the wind. In addition to this, certain fruits are evidently intended for dissemination by this agency, for they are furnished with downy tufts or with wings which support them on the breeze. When ripe for dispersion, the light, flossy seeds of the Dandelion and the Thistle may be seen floating in considerable quantities on the softest wind. These special appendages, though designed to serve the same purpose, and though often similar in appearance, vary greatly in their origin. There are three kinds of wing-shaped processes which, while the fruit is developing, take their rise from different parts of the flower. The wings on the seeds of certain species of the Pine Order arise from an outer layer of the tissue of the scale; those on the seed of *Bignonia muricata* from the coat of the ovule, and those on the samaræ of the Elm and the Maple are developments from the pericarp, which, of course, in simple fruits is the matured ovary. Again, the silky tuft of hairs, or pappus, of the Compositæ and of kindred orders, is a peculiar development of the calyx; whilst the coma of the seeds of Asclepias and of the Willow is a hairy growth from the testa. Aided by these special formations on seeds and fruits, the importance of the wind in the work of dissemination is difficult to overestimate.

Frequently the wind acts in conjunction with another outside agent of dissemination—water. The wind strips the vegetation of a district of its fruits and carries them into neighbouring streams, to be caught perhaps by the bend of a bank where they form a colony. Plants growing by the banks of rivers will thus be distributed along the course of the stream. Curiously enough, it will sometimes happen that an Alpine plant will in this manner be brought into a lowland district where the climatal conditions are not favourable to its growth. It may flower, but cannot produce seed, and it is only by the continual renewal of the seed by the current that the species is able to maintain its occupation of the uncongenial locality. Certain seeds will, however, be borne by the current right out to sea, where, with others which have been carried

direct to the ocean by the wind, they may probably flourish on some remote island. Necessarily such seeds must be well protected against outer injury, whether from friction or from the action of salt water. Dr. Hooker found in his examination of a large number of the floras of islands that the Leguminosæ, to which order the Pea, the Vetch, and the Bean belong, contained more species common to other parts of the world than any other order. The preponderance was due to the characteristic form of the fruit, its strong pericarp being well adapted for preserving the seed, whilst its shape enabled it to float on the water.

Of course, it is only fruits of a certain lightness and buoyancy that admit of transport by wind and water. Those that are too heavy for this method of distribution, such as pulpy fruits, depend upon the agency of animal life for dispersion. There can hardly be any doubt that the bright, succulent, and edible coverings of fruits are specially intended to attract the attention of birds and other animals. In order to produce this attractive exterior we find not only the ovary—afterwards the pericarp proper—specially developed, as in the Orange or the Grape, but various other parts of the flower.

Thus, by structural developments adapted to take advantage of the means of transport existing in the forces of wind and of water, and in the surrounding animal life—affording another proof of the interdependence which exists in Nature—have plants been spread over the Earth. "The real difficulty," says Sir Charles Lyell, "which must present itself to everyone who contemplates the present geographical distribution of species, is the small number of exceptions to the rule of the non-intermixture of different groups of plants. Why have they not, supposing them to have been ever so distinct originally, become more blended and compounded together in the lapse of ages?"

CALCITE AND ARAGONITE IN SHELLS.

By Vaughan Cornish, B.Sc., F.C.S.

If different materials have the same chemical composition, they are generally regarded as being essentially identical, and are looked upon as *varieties* of the same substance. Carbonate of lime is a familiar example; chalk, limestone, marble, Iceland spar, and aragonite are all composed of carbonate of lime, and are spoken of as different varieties of carbonate of lime. This does not, however, represent the view of the mineralogist. Chemical composition is only one among several criterions considered in the definition of a mineral species. It often happens that minerals differing fundamentally in their crystalline form, and in the internal structure which is connected with the external form, have the same chemical composition. These are regarded by the mineralogist as distinct species, notwithstanding the identity of chemical composition. Fundamental difference of crystalline form is the basis of differentiation among minerals of which the composition is identical. We will endeavour to make clear the principles on which it is decided whether a difference of form is to be regarded as fundamental. In mineralogical collections, ranged side by side with the well-known rhomb of Iceland spar, may be seen a vast variety of crystalline forms of carbonate of lime. In general appearance they differ greatly from one another; yet the mineralogist will tell one that there is no *fundamental* difference in these forms, which are all intimately related to that of the rhombohedron. This relationship is a matter of geometry, which we must be content to state merely in a general manner. A crystal is a body bounded by certain plane surfaces—the faces of the crystal. The arrangement of a system of planes is best understood by considering how their position is related to three lines intersecting at a point, these lines being termed *axes*. A crystalline form is defined, first, by the position of these lines; secondly, by the manner in which the position of the planes is related to that of the lines. All the various forms which, in the mineralogical collection, are placed in proximity to the rhomb of Iceland spar, are forms which can be built up on the same system of axes, and the positions of the planes or faces with respect to these axes are all related to one another according to a simple geometrical law. All these specimens are, therefore, reckoned as belonging to one mineral species, to which the name *calcite* is given.

In the next compartment of the mineralogical collection will be found another set of crystals, also composed of carbonate of lime. These, however, are members of another mineral species known as *aragonite*. Their forms are related among themselves by a simple geometrical law, but the plan of construction is radically different from that of the calcite forms. The system of planes representing the faces of the crystals cannot be built up on the same three axes as those of the calcite forms, and the law connecting the positions of the planes themselves is different in the two cases.

For the mineralogist, carbonate of lime comprises two mineral species—calcite and aragonite—and all the different varieties are classed under one of these two names.

The question may be asked, Is there not something fanciful in basing a classification of material substances merely on certain abstract ideas of symmetry? Calcite and aragonite are composed of the same kinds of stuff or matter; if our minds were not gifted or encumbered with abstract notions about symmetry, should we discover any difference of properties between these two mineralogical species? As a matter of fact, the properties of crystalline substances furnish a striking example of the real and intimate relation of our ideas of symmetry with the actual constitution and properties of matter. Every property of a crystalline substance is related to the particular symmetry of its form. Thus, take the case of the action of the substance upon light. A ray of light is affected in the same way by its passage through any crystal of calcite; all specimens of aragonite behave alike in their action on light; but the mode of action is entirely different in the case of aragonite from that of calcite. For exhibiting these differences of behaviour in the most distinct manner an elaborate instrument is employed, the stauroscope, in which *polarized* light is used. We cannot enter here into the method of using the instrument, but in most text-books of mineralogy will be found plates showing the different *interference* phenomena afforded by a crystal of calcite and one of aragonite. A fragment of a crystal shows the phenomena characteristic of its species, which do not depend upon the specimen possessing crystalline faces. The action upon light depends upon the actual structure of the material of which the crystal is composed, which, as the above example shows, is intimately related with the crystalline form. We see, then, that the physical properties justify the mineralogist in sorting the varied crystalline forms of carbonate of lime into two classes, and in characterizing every member of each class by one of two names—the names of two mineral species.

We have said that *all* varieties of carbonate of lime are classed as calcite or aragonite, and many of these varieties do not show crystalline form at all, as, for instance, limestone and marble. What data justify the

mineralogist in calling limestone and marble calcite? We have said that where crystalline symmetry differs, all physical properties are different. One of the most important, and one of the most nearly constant properties of every kind of matter, is its specific gravity. Every specimen of calcite has a specific gravity of 2·72, or not differing from 2·72 by more than one or two units in the second decimal place. Similarly all specimens of aragonite have a specific gravity of very nearly 2·93. In limestone and marble we have the so-called *massive* carbonate of lime, the material not having had the opportunity to assume the crystalline form. How are we to determine whether limestone is calcite, aragonite, or yet another mineral species? The specific gravity is found to be that of calcite, viz. about 2·7, as is also the case with marble. We conclude, therefore, that the carbonate of lime in limestone and marble is calcite.

It has long been a familiar fact that certain organisms have the power of secreting carbonate of lime from solution to build up the hard portion of their shells. The shell of the oyster, for instance, of the crab, and of the common whelk are complex structures of organic matter and carbonate of lime, and in the fossilized remains of shells the general form of the shell is preserved by the carbonate of lime after the decomposition of the organic matter. Several questions of interest are suggested by this case of combined mineral and animal growth. Does the carbonate of lime in calcareous organisms exist in some special modification different from those known in the mineral world? How far is the mode of growth of the animal tissues constrained by the rigid laws of crystallization? Or, on the other hand, do the forces brought into play in animal growth mask, or even overpower, the operation of the ordinary process of the crystallization of a substance from solution? The answers to these questions are furnished by the investigations of Dr. Sorbey and others, which have been published at intervals during the last twelve years. In the first place, it has been shown that in calcareous organisms we have *not* to deal with any new species of carbonate of lime. In every case the optical properties and the specific gravity show that the shells contain either calcite or aragonite. Some animal species secrete carbonate of lime as calcite, others as aragonite.

The mode of growth of the shell is in general a compromise between the mineral and the organic, in some cases the influence of the first factor having the predominance, in others that of the second. The direction of the *principal axis* of the crystal is always related in a definite manner to the surface of growth of the shell—the symmetrical arrangements which result from this relation producing very beautiful appearances when sections are examined under the microscope. Thus the inner shell of *sepia* (the cuttle-fish) shows innumerable crystals of aragonite ranged in parallel rows, whilst the mineral portion of the spines of *echinoderms* consists of a single crystal of calcite greatly developed in one direction.

Some organisms, as we have said, secrete or produce calcite, others aragonite. Other cases again are known in which one portion of the shell is built up of, say, aragonite, and during the subsequent growth of the organism its habits or powers undergo a change, the rest of the shell being built up of calcite. It will be seen that we are dealing with a mixed study, at once mineralogical and biological. It is peculiarly interesting to find that the influence of the laws of evolution is apparent even when studying the mineralogical aspect of the subject. It is well known that the embryo shows the past history of the species, the development of the individual furnishing an epitome of the history of development in the race. Now the shell of the common whelk, which may be found on any sea-beach, is composed of calcite, except a small portion which is that *first* formed in the growth of the organism. The examination of the *fossil* species of the whelk tribe shows that they are composed wholly of aragonite, the composition of the whole shell of the early individuals of the race being identical with that of the embryo of their modern representative.

It was long since observed that in fossiliferous beds which are permeable to water, certain calcareous shells are preserved, whilst others are only represented by their impressions. This is the more remarkable, because some of the most massive shells have disappeared whilst others of delicate structure remain. The form of the impression enables the species of the shell to be identified, and it is found that the shells which have been removed are those of species known to secrete their carbonate of lime as aragonite. It was known that under many conditions aragonite is less stable than calcite, and it was assumed from the above observations that aragonite is more readily dissolved than calcite by water containing carbonic acid. A few years ago this point was made the subject of experimental investigation, with somewhat singular results. Pure and well crystallized specimens of calcite and aragonite were subjected to the action of a solution of carbonic acid under similar conditions. No difference of solubility was detected. Powdered calcite and aragonite fossil shells gave a like result. It was found, however, when the complete shells were suspended in a solution of carbonic acid, that those of aragonite were much more readily acted upon than those of calcite, and further that the coherence of the shells was soon destroyed, so that the slightest agitation of the water was sufficient entirely to disintegrate the shell, reducing it to the condition of a fine powder or mud. The disappearance of aragonite fossils is explained by these experiments; it is due not to the greater solubility of aragonite, but to a mode of structure of shells composed of aragonite which facilitates their solution and disintegration.

The experiments gave somewhat unexpected results also in the case of calcite fossils. It was found that they were acted upon with considerable rapidity by the solution of carbonic acid, but that they retained their compactness, and even the delicate details of marking, after losing as much as 15 per cent. of their weight through the action of the solvent. It is thus evident that the calcite fossils found in porous or permeable beds *simulate* an immunity from the action of carbonic acid which they do not in reality enjoy. In such beds as these a large quantity of carbonate of lime goes into solution, and cavities are formed having the shape of the fossils which have been removed. It frequently happens that at a subsequent period carbonate of lime crystallizes out from solution in these cavities. When crystallization takes place at the ordinary temperature calcite is formed, a fact which is readily established by laboratory experiments. Consequently *casts* are formed in calcite of aragonite fossils. They are readily distinguished from the originals by their translucency, aragonite fossils being always opaque. Thus the beautiful *ammonites* often found of a material resembling fine alabaster are repliquas only, no trace of the original aragonite shell remaining. Many other such cases occur.

In conclusion, we may point out that the investigation of the subjects dealt with in this article involves the application of chemistry, mineralogy, and palæontology. The work has been taken up from time to time by students of one or other of these sciences, but the subject as a whole belongs to a sort of no-man's land in science. The border-

Head of Rameses II., the Pharaoh of the Oppression
Found January 9th, 1891, in a mound of rubbish outside a Temple facing the Nile at Luxor.

Direct Photo Eng. Co., Lim., 9, Barnsbury Park, N.

Intaglio Picture of the Front of the Temple of Rameses II.
As it existed at the time of its dedication to Amun-Ra. Uncovered 7th January, 1891.

lands of the different sciences are apt to be somewhat neglected, but often yield a fruitful harvest to an investigator properly equipped for his work.

EXCAVATIONS AT LUXOR.

By CANON ISAAC TAYLOR.

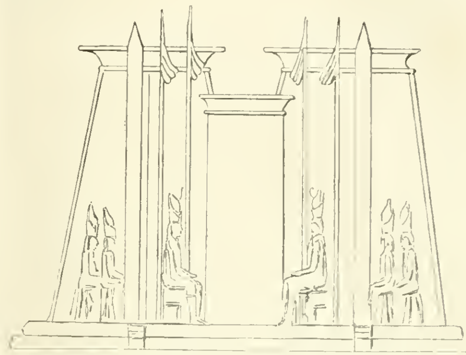
LUXOR is one of four or five villages occupying portions of the site of Thebes, at one time the greatest city in the world. These villages, mere collections of mud huts, were built in the chambers and against the walls of temples and palaces, which were grouped in certain parts of the area of the ancient city. The word Luxor is merely a corruption of the Arabic name *El-Kusur*, which means "the palaces," and was applied to a range of connected temples extending for nearly a quarter of a mile along the eastern bank of the Nile. These temples were, till recently, buried under a vast mound of *débris*, some twenty or thirty feet in height, consisting of broken pots, the refuse of habitations, and the crumbled mud bricks of successive huts and houses of unburnt brick which had accumulated during the last 1,400 years. The sections of these refuse-heaps show in some places fifteen to eighteen strata, the strata representing successive houses, each built on the ruins of a house which had formerly occupied the site. By the means of the new tourist tax—a tax of £1 now levied on each visitor who ascends the Nile—these temples are rapidly being cleared from the rubbish which is piled up in their courts and colonnades, and the sculptured scenes which cover the walls are being daily exposed to view.

During the present season, 1890–91, the great temple of Rameses II., the Pharaoh of the Oppression, has been nearly cleared. Outside the northern portal, which fronts the Nile, are two colossal statues of Rameses, monoliths of red granite in a standing position; while the more important entrances, those to the east and the west, are each guarded by two seated statues of the same king, monoliths of black granite. The scale is rather more than six times the size of life, and as each statue is surmounted by the lofty crown of Upper Egypt, they would, if in an erect position, have represented figures nearly forty feet in height. Unfortunately most of them have been defaced by iconoclastic zeal, the faces especially being mutilated. In one case, however, the destroyers, instead of mutilating the features, succeeded, with the aid of wooden wedges inserted into holes bored behind the neck, in detaching the whole of the head. In its fall the head broke in two pieces, the crown breaking off at the forehead. In the first week in January this gigantic crown, about four feet in height, was discovered by the excavators, and a few days later they came upon the head itself, the face being absolutely uninjured, and wearing the placid smile of amused contempt with which the features of Rameses were commonly represented by the sculptors of his court. The picture to the right hand is from a photograph taken a day or two after the head was uncovered. The Arab seated beside the head is a tall man, not far from six feet in height.

ROYAL CROWN.

Two days before this discovery was made, the workmen uncovered a portion of the inner wall of the temple, on which is sculptured a most interesting representation of the dedication of the completed temple to Amun-Ra. On a portion of the wall, about six feet by four, we find in shallow intaglio a picture of the temple as seen from outside the western pylons, a picture which disposes of sundry conjectural restorations of Egyptian temples, and shows how the pylons, obelisks, and flag-masts were arranged.

The picture engraved upon the wall is on a scale of about 1 to 22. It shows the two gigantic pylons, which have suffered little injury, and between them is the lofty portal,



THIS SKETCH IS THE SAME AS THE INTAGLIO PICTURE OF THE FRONT OF THE TEMPLE IN THE PHOTOGRAPH.

which has now entirely disappeared. In front of each of these pylons stood an obelisk of red granite. That to the left is still standing, though buried for about a third of its height in rubbish. The fellow obelisk to the right is now in the Place de la Concorde,* at Paris. Two gigantic masts, bearing flags, stood in front of each pylon. The stone attachments for these masts can still be traced. To judge by the scale, the masts must have been more than seventy feet in height, and the flags must have floated from them at about the height of the pylons. The pylons were guarded by six colossal statues of Rameses—two in a sitting posture, and four erect. The seated figures are now nearly buried in rubbish, leaving the heads only above ground. Of the standing statues the one farthest to the right has been dug out, and is in fair preservation, the accumulation of soil having reached above the head. Of the next standing statue nothing remains. Of the two standing colossi to the extreme left in the picture nothing can be seen; but, as the soil is undisturbed, they may possibly be found, either in fragments or *in situ*, when the excavators have reached that portion of their task.

The picture has decided another interesting point. From other temples it is known that the pylons were provided with internal staircases by which their summits could be reached. Within the last fortnight† the excavators have discovered the internal staircase leading to the summit of the great temple of Rameses III. at Medinet Haboo. Now it will be observed in the drawing that near the foot of each of the obelisks three steps are indicated, and these must be the lowest steps of the staircases which led to the summits of the pylons. We know, therefore, that by the removal of some twenty feet of rubbish the excavators will come upon the entrance to the staircase, which, it may be hoped, will prove so far uninjured as to make the ascent practicable.

It may be mentioned that the western faces of the

* The actual height of the obelisk in Paris is 82 feet, while the representation of it in the wall picture is 45 inches high, giving 1 to 22 as the scale. Tho masts must have been something like 80 feet high. Where did Rameses obtain such timber?

† The article was written by Canon Taylor at Luxor, and posted 20th January 1890.—A. C. RANYARD.

pylons are covered with battle-scenes, representing the Syrian campaign of Rameses II., including the battle under the walls of the city of Kadesh on the Orontes.

In the interior of the temple, in addition to the seated colossi already mentioned, eleven gigantic standing statues in red granite have already been unearthed, and there must be three more beneath the floor of a mosque which still occupies the south-western corner of the temple. These, on account of the religious prejudices of the people, cannot, for the present at least, be unearthed.

The mutilation of the faces of the figures is probably due to the fanaticism of the early Christian hermits of the Thebaid, who regarded them as idols. Fortunately there is no such danger from the Moslems, who, though iconoclasts, do not regard the statues as images or idols, but believe that they are the bodies of their own ancestors, who, as a punishment for their sins, were turned into stone by Allah. The other day one of these statues was unearthed, and the next day at early dawn three Arab women were found solemnly walking round it, and performing suitable funeral ceremonies, as if around the body of one of their own dead.

The following extract from a translation of a private letter addressed by M. Grébaut, director-general of the excavations, to his learned predecessor, Professor G. Maspero, of Paris, was printed in the *Times* of March 2 :—

"Having found, *in situ*, at Deïr-el-Bahari, a royal sarcophagus of a queen, and seeing that the surrounding ground had not been disturbed, I thought it worth while to make further excavations on the spot.

"At a depth of 15 mètres we came upon the door of a rock-cut chamber, in which were piled, one above the other, 180 mummy-cases of priests and priestesses of Amen, together with a larger number of the usual funerary objects, including some fifty Osirian statuettes. Of these, we at once opened ten, finding a papyrus in each.

"There are a great many enormous wooden sarcophagi, containing mummies in triple mummy-cases, all very richly decorated. Among these we have found a priest of Aah-hotep. These sarcophagi are of the time of the 21st dynasty. What we have found is, therefore, a 'cache' of the same period as that of the royal mummies discovered in 1881, and made by the same priests of Amen.

"Notwithstanding that the soil has remained untouched for 3,000 years, some of these sarcophagi are broken, and many of the gilded faces of the superincumbent effigies are injured. The way in which they are piled up, their damaged condition, and the general disorder, point to a hurried and wholesale removal, as in the case of the royal mummies. We find, for instance, a mummy-case inscribed with one name, enclosed in a sarcophagus inscribed with another, while probably the inner cases may prove to belong to a mummy with a name differing from both. May we here hope to find some royal mummies for which there was not space in the vault discovered ten years ago? I scarcely dare to hope it.

"At a first glance it would seem as if the high priests had abstained from burying the mummies of their more humble predecessors with those of royalty. Everything must, however, be opened and studied.

"About midway in the shaft now open may be seen the door of an upper vault; and, to judge by certain indications, there is also probably an intermediate vault; had we, however, only the 180 sarcophagi contemporary with, or anterior to, the 21st dynasty, it would be a magnificent haul, the greater number of the sarcophagi being really splendid and in perfect preservation. There are also some charming things among the minor objects.

"The name has been purposely erased, or washed off, from several of the large sarcophagi, and the place left blank, as if the scribe had not had time to fill in that of the new occupant; but we may probably find the names of those later occupants on their inner mummy-cases. One of the largest of these sarcophagi is surcharged with the name of the High Priest of Amen, Pinotem.

"As soon as we have cleared the lower vault I shall attack the upper chamber, or chambers."

Letters.

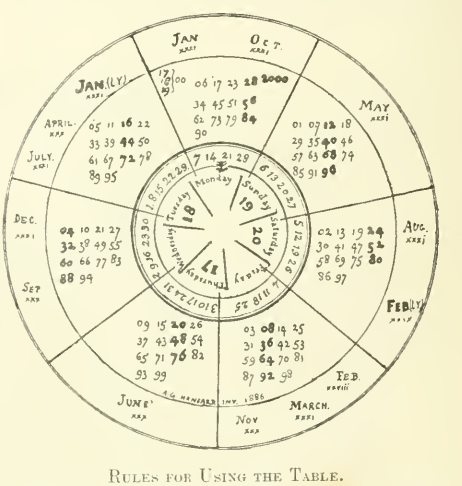
[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

PERPETUAL CALENDARS.

To the Editor of Knowledge.

Sir,—I was much interested in Mr. Prince's calendar, inasmuch as I designed one myself on much the same lines a few years since. Mine, however, seems to have some advantages for finding the days of the week in past centuries (especially in the Old Style). I therefore enclose a copy and the rules for using it, in case you should think it of sufficient interest to reproduce for the readers of Knowledge.—Your obedient servant,

Arnold S. Hansard.



Rules for Using the Table.

I.—The numbers in the ring next within the names of the months are the last two figures of the years; the numbers in the ring next inside this are the days of the month. The numbers on the movable disc refer to the first two figures of the years (*i.e.* when the given date is within the years 1700 and 2099 N.S.).

II.—To find the day of the week of any given date (N.S) where the first two figures of the year are given on the movable disc; firstly, bring that number opposite to the last two figures of the given year; secondly, note which day of the week is thus brought under the small arrow at the top of the movable disc, and bring that day

of the week under the required month. The days of the week are now opposite their proper days of the month.

III.—If the year is given in thick figures it is a Leap Year, and the January and February in thick letters must be used; in other cases the plain January and February must be used.

IV.—The table may be used for any other centuries (N.S.), the calendar being repeated every fourth century. Thus 1600–1699 is identical with 2000; 2100 with 1700; 2200 with 1900, &c.

V.—For Old Style dates, in the first motion of the disc, the day of the week given in the following table must be set opposite to the given year; the second motion being the same as in New Style dates:—

Hundreds (Old Style).			Division of Disc.
—	18	11	Sunday
—	17	10	Monday
—	16	9	Tuesday
—	15	8	Wednesday
—	14	7	Thursday
20	13	&c.	Friday
19	12		Saturday

N.B.—That the years 1600, 1700, 1800, &c., are all leap years, O.S.; but only every fourth of them, *e.g.* 1600, 2000, 2400, &c., are leap years according to N.S.

THE MAGIC SQUARE OF FOUR.

To the Editor of Knowledge.

Dear Sir,—For the sake of accuracy, I should like to point out a mistake in my estimate of the number of varieties of type D. The types A, B and D are mutually convertible by a few simple transpositions, and therefore must have the same number of varieties. Now it is mathematically demonstrable that there can be only 48 varieties of A and B; hence there must be just 48 of D. How it happened I wrote 96 I do not know.

On the other hand, Mr. Cram tells me he can make 56 each of G, I, J, and L. Consequently, we are still 32 short of Frenicle's total of 880.

T. S. Barrett.

To the Editor of Knowledge.

Dear Sir,—In reading Mr. J. Pentland Smith's very interesting article on "Contrivances for the Cross-Fertilization of Plants," in Knowledge, Feb. 2, 1891, I have been completely puzzled by the following problem:

In speaking of the case of *Aspidistra elatior*, Mr. Smith, either in his own words or quoting Dr. Wilson, says in effect:—

(I.) There is no access to the pollen until the stigma is fertilized.

(II.) Fertilization cannot be effected until pollen has been deposited on the stigma.

What I want to know is: How is the first flower fertilized, so as to commence the process?

Yours faithfully,
F. J. Provis.

Coleford, Gloucester, 16th March 1891.

[Until the decay of the stigma the slugs cannot get to the pollen. One can easily imagine that sooner or later the stigma of the first flower of the season will decay, whether pollenated or not, and that then access can be obtained to the pollen below. Pollenation, that is the resting, and ultimate germination of the pollen on the stigma, precedes fertilization in all Angio-sperms or plants which have their seeds enclosed by the carpels.—J. P. Smith.]

STELLAR SPECTRA.

By E. W. Maunder, F.R.A.S. (*Assistant superintending the Spectroscopic Department of Greenwich Observatory*).

When the publication of Dr. Elkin's determination of the parallax of Arcturus rendered it probable that we must class this star as one of the most distant of its magnitude, it became clear to me, as I tried to show in the February number of Knowledge, that it must be of most gigantic size, and must move with most amazing swiftness. But a further point for inquiry also suggested itself. If Arcturus be, as would appear to be the case, the star which actually gives the most light of any we know of at present, then its spectrum should be typical of the largest and hottest stars, whereas it has been customary to regard it as of a markedly lower class.

The subject of the classification of stellar spectra has been occupying special attention of late; it may, therefore, be worth while to see if any further light, however feeble, can be thrown on the matter from the point of view suggested by the magnitude of Arcturus.

The earliest classification of stars was effected by Sir W. Herschel, who grouped them according to their colours; the only arrangement possible at a time when the spectroscope was still undreamed of, but a real step, nevertheless, towards the more delicate discrimination which that instrument renders possible. Fraunhofer, in his endeavours to solve the secret of the spectrum, noted the strongly marked differences between the spectra of different stars, and drew the important conclusion that the dark lines which crossed them were due to something in the stars themselves, and not to any effect of our own atmosphere, or any absorption of light in space. But the first spectroscopic classification of stars was due to Rutherford in America, and Secchi in Europe. The latter, as was inevitable in beginning so new a research, made several alterations from his first scheme; but his final classification divided the stars into "types" of spectrum as follows:—

Type I.—The white and bluish white stars, like Sirius and Vega. The spectra in this type show the four lines of hydrogen intensely dark, broad, and with diffused and shaded edges. Metallic lines are faint and narrow, and not easily seen. The principal stars of Orion form a variety of this type, in which the hydrogen lines are much less marked, and much narrower than in other stars of the first type.

Type II. embraces the yellowish stars, such as our Sun, Arcturus, and Aldebaran. The hydrogen lines are well seen, but narrow and fairly sharp; the entire spectrum is full of well-marked metallic lines, some of which are more pronounced than the lines of hydrogen.

The stars of Type III. are mostly orange in hue; α Orionis and α Herculis are the best examples. The hydrogen lines are faint, or no longer seen; but a succession of dark bands, dark and sharp towards the violet, and shading away into nothingness towards the red, makes this type of spectrum the most strongly marked and the most beautiful of any.

Type IV., the stars of which are mostly red, also shows a banded spectrum, but the bands fade off in the opposite direction to those of Type III.

Secchi further called attention to the existence of a couple of stars showing *bright* lines in their spectra, the forerunners of a fifth type; and, a little later, the discovery by MM. Wolf and Rayet of a curious group of stars in Cygnus added a sixth type.

Secchi's classification was purely an observational one, and it was independent of theoretical considerations as to

the respective ages in the evolution of a normal star which the different types might represent. For it was naturally felt that there must be growth and development amongst stars as amongst animals and plants. A star must have its birth, its periods of growth, full vigour, and decay, closing in the—

Last scene of all
That ends this strange, eventful history,

a dark, cold body, incapable of giving light and heat to other worlds, or of sustaining life upon its own surface. And naturally the attempt was made to connect these different types of spectrum with the various stages of stellar life-history. Zöllner seems to have been the first to suggest that the white stars were the hottest, and that the yellow colour of the stars of the second type showed that they had advanced some way in the process of cooling down. Angström suggested that the shaded bands of the orange stars indicated the formation of compound bodies in their atmospheres, consequent on the lowering of temperature; and Lockyer, a little later, expressed the same views still more definitely. "The hotter the star, the simpler its spectrum," he said; "and the older a star, the more does the free hydrogen disappear from it." Vogel, more recently, being dissatisfied with Secchi's mode of grouping stellar spectra, devised a more elaborate one, the principal change from Secchi's system of Types being that Vogel makes Types III. and IV. varieties of the same Class III. The leading thought in this new classification was that all stars have at one time or another been of the first or Sirian Type, all will pass through the second or Solar Type; but after passing this stage the star may either show a spectrum like that of α Herculis, or like that of the small red stars. The road diverges here; the majority follow the path which Antares, Betelgeuse, and the *lucida* of Hercules have taken; but a few, especially the stars in two small groups on the Milky Way, prefer to give spectra in which the bands are sharpest to the red, and shade off towards the violet.

It was well objected to this scheme that it made no provision for a period of increasing temperature in a star. Stars are certainly not brought forth from nebulæ, like Pallas Athene from Jupiter, fully developed and equipped with their whole armoury of light and heat. There is evidently a time during which the surface brilliancy increases, and this probably corresponds with a time during which the mean temperature must be increasing. Besides, the place assigned to the red stars was a perfectly arbitrary one. We know that the First and Second Types are contiguous stages, whichever be the earlier; for stars like Procyon, Rigel, Spica, Polaris, α Cygni, and others, supply examples of almost every possible gradation, from the unmistakable Sirian to the complete Solar form. So, again, Aldebaran, Betelgeuse, and many others form a series of links connecting the Second and Third Types; but until recently the Fourth Type stood alone. There are no instances of stars whose spectra leave us in doubt as to whether the Fourth Type or some other is the more strongly represented; there are no intermediate forms. It is therefore a pure assumption to assert that this particular kind of spectrum is either the next stage to the Solar Type or that it is an alternative stage to the α Herculis Type.

The most recent classification is that of Lockyer, and he certainly avoids one of the objections to which Vogel's is open. The Sirian Type is still taken as that of the hottest stars, but he breaks up the Solar Type into two groups; the one showing rising, and the other falling temperature. The course of evolution, according to his plan, is: Group I., the nebular stage; Group II., the orange star, or α Herculis stage; Group III., the α Cygni stage, including some spectra of Secchi's Type II.; Group IV., the Sirian stage; Group V., the Solar stage, including the rest of Secchi's Type II. stars; Group VI., the red star stage; Group VII., the dark stage. The position assigned to the red stars is, of course, as much a matter of assumption on Lockyer's plan as on Vogel's. The former has, however, this advantage over his predecessors, in that it corresponds to the probable stages of growth as well as those of decay. The Sirian stars, which he, in common with almost every theorist,* regards as the hottest and largest, mark not only the commencement of a fall in temperature, but the conclusion of a rise. We are saved the difficulty of assuming the Sirian phase to be that in which all stars were originally created, and from which they have only changed by degradation.

But in all these systems the supremacy of the Sirian Type is assumed, not proved, and it has been well pointed out that it is quite possible to read the record the other way, and to argue that the ruddy stars are the hottest, and that the orange, yellow, and bluish tints are evidences of a progressive decline in temperature. It is a question, therefore, of much importance to see if any positive information can be given us on the subject.

Two circumstances have greatly operated to the present view. Firstly, that a solid body raised to incandescence first glows with a ruddy hue, and then, as the temperature increases, so the colour changes to orange, yellow, white, or blue; and it was very natural, though scarcely scientific, to extend the analogy to the stars. For a stellar spectrum shows us by the continuous band of colour, interrupted by dark bands, that the light we receive is not the whole of the light the star emits, but that it has suffered absorption in the atmosphere of the star itself; and it is in the differences of the quality and amount of this absorption, and not in the differences of the original light of the star, that we find the tests for distinguishing one type from another. That is to say, it is by the dark lines or bands, and not by the continuous spectrum, that we classify the stars. The difference, therefore, between the Sirian and Solar stars lies not in their photospheres, but in their absorbing atmospheres. For Sirius such absorption is almost confined to hydrogen, the influence of which is excessively marked; but for the Sun, Arcturus, and their congeners, twenty or thirty elements have impressed the spectrum with the evidences of their presence. Given that two stars of these two Types are at the same distance from us, and that they appear to shine with the same amount of light, surely the star which displays the

* In this, as in other departments of science, the inductive method is the only safe one, and a few observed facts are preferable to any number of theories founded on assumed conditions. The physical connection of the trapezium stars with the Orion nebula, and the stars of the Pleiades cluster with the Pleiades nebula, can hardly be doubted; and if the nebular stage is the first one in a star's history, we have evidence that three different classes of spectra are exhibited by stars involved in nebulous matter. In all three the hydrogen lines, or some of them, are conspicuous, but the spectra are considerably more complicated than those of stars usually ranked as belonging to Secchi's First Type. The spectra of the trapezium stars appear to be crossed with bright lines similar to, but more intense than, the bright lines of the Orion nebula around them; the hydrogen lines are not hazy and diffused as in Secchi's First Type, but comparatively narrow and sharp. The two classes of spectra in the Pleiades group each include stars of various magnitudes; and if we may assume that all the stars of the Pleiades group are of the same age, we must conclude that the two classes of spectra do not correspond to different stages of cooling. The star which appeared in the Andromeda nebula in 1885 seems to have had a spectrum terminating abruptly at the red end, as well as, according to some observers, very faint bright lines, which are asserted to exist in the Andromeda nebula spectrum. The facts brought together by Mr. Maunder in this paper should check too precipitate theorists.—A. C. Ranyard.

greatest indications of absorption in its spectrum must be actually emitting the greatest amount of light from its photosphere.* And, to say the least, it is arguable that the fuller development of the metallic spectra in stars of the Second Type shows a higher temperature, not a lower one. It is conceivable, not to put it more strongly, that an intenser heat may in these stars keep metals in the state of absorbing gas, and at a higher atmospheric level, which in Sirian stars are precipitated at or below the photosphere, and so give no sign of their presence. At all events, we can feel well assured that the temperature of the Solar stars is very high, for not only do we find the metallic lines in the visible spectrum, but we find them strongly marked and numerous far in the ultra-violet, a proof that even in the reversing layer the temperature is high enough to compel the metals whose gases compose it to give out radiations of even the shortest wave-lengths, and to give them out strongly and unmistakably.

The other circumstance that has led to the belief that the white stars are the hottest, the red the coolest, is that whilst more than half the stellar giants are of the first type, there are only two 1st-magnitude stars of the third type, and the brightest of the fourth-type stars is not so bright as the 5th-magnitude. But, again, a closer consideration of the facts leads us to a different conclusion. Surely we have no right to assume that the stars are equally distributed amongst the various Types. If they really mark different stages in stellar evolution, some may be much more quickly passed than others; or it may be that but few stars are yet old enough to have reached the most advanced stage, or else that but few are so young as not to have passed through at least one phase. There is, however, a simple test which we can apply. If the orange or ruddy stars are fainter on the average than the white and yellow, then the further down in brightness we go the larger will be the proportion of such stars observed. But this does not appear to be the case. If we take those stars of the Oxford Uranometria which are above the 5th magnitude, and have been classified by Secchi, we find them thus divided :—

	Type I.	Type II.	Type III.
Above 1st mag.	5	2	1
Between 1st and 2nd ...	11	4	1
,, 2nd and 3rd ...	20	17	4
,, 3rd and 4th ...	50	54	2
,, 4th and 5th ...	35	29	2
	121	106	10

The stars of Orion and of the Pleiades which have spectra a little differing from the normal type, have nevertheless been included under Type I. Excluding these, and such stars as were outside the general Oxford limit of North Polar Distance (100°), and were only observed on account of their special brightness, we find that for the stars north of 10° S. Dec., and above the 5th magnitude, the numbers would run :—

	Type I.	Type II.	Type III.
Above 1st mag. ...	2	2	1
Between 1st and 2nd ...	8	4	0
,, 2nd and 3rd ...	18	17	4
,, 3rd and 4th ...	15	54	2
,, 4th and 5th ...	33	29	2
	106	106	9

It would seem then that, within these limits, the first and second types are about equally numerous, and each about twelve times as abundant as the third.

Comparing these numbers with the results of Vogel's and Konkoly's spectroscopic surveys, which were carried down to the 7½ mag., we find that they give out of 6,073 stars examined the numbers for each type as follows :—

Type I.	Type II.	Type III.	Type IV.
3,145	2,105	375	12

besides 14 stars of the Orion variety of Type I. and 122, that could not be properly classified under any of the above heads.

The comparison shows that, so far as these observations go, Type I. has a small preponderance over Type II. for the higher magnitudes, but that this preponderance ceases between the 3rd and 4th magnitudes to become much more marked as fainter stars are included. Three conclusions seem to be fairly deducible from this result. First, that Sirian stars are more numerous on the whole than Solar stars. Secondly, Solar stars are on the average rather brighter than the Sirian stars, or else rather nearer to us. Thirdly, that the average difference in the brightness of the stars of the two Types is not by any means so great as we should expect if either Type marked a stage of very greatly superior temperature to the other.

Of course the materials I have used are very incomplete and can only supply indications, and not proofs. Still, it may be worth while to take the question a stage further, and see what light parallax determinations have to throw on the question.

Taking the table of parallaxes given in the appendix to Miss Clarke's *System of the Stars*—a book as valuable and instructive as it is charming in style—we find 20 stars the parallaxes of which are given, and which are found in Secchi's lists of star Types. Adding Arcturus we have 21, of which nine are First Type, and 12 Second Type stars. Employing the Oxford magnitudes and computing the absolute light-giving power of each star, taking Sirius as our standard, we obtain the following table :—

Sirian Stars.		Solar Stars.	
β Cassiopeiæ . .	0·29	α Cassiopeiæ .	1·11
α Persei . .	1·96	η Cassiopeiæ .	0·12
Sirius . .	1·00	β Andromedæ .	0·98
Procyon . .	0·56	Polaris . .	4·45
Regulus . .	2·55	α Arietis . .	1·39
α Lyræ . .	48·35	Aldebaran . .	1·68
α Draconis .	0·04	Capella . .	5·11
α Aquilæ . .	0·61	Pollux . .	3·92
α Cephei . .	1·60	η Herculis . .	0·15
		π Herculis .	0·19
		ε Cygni . .	0·50
		Arcturus . .	117·00

It will be seen at once that two stars stand out from all the rest; Vega amongst the Sirian stars being nearly six times as bright as the other eight taken together; and Arcturus, amongst the Solar stars, more than seven times as bright as all the eleven others taken together. In both cases the parallax adopted is that of Dr. Elkin, which for these two stars, and especially for Vega, differs

* If the stars are all composed of similar materials (as has been, perhaps, too hastily assumed), and their photospheres are clouds of incandescent particles. The temperature of their photospheres could not exceed the highest temperature at which the most refractory materials would be driven into vapour, and all photospheres would shine with equal brightness. That there are differences in the apparent brightness, area for area, of stars can hardly be doubted from the facts we have already learnt with regard to the masses of double stars; such, for example, as Sirius and his companion, and the binaries of the Algol type.

From the facts we know with regard to our own sun we cannot suppose that the matter of gaseous stars is stratified at different levels, as some theorists have too hastily assumed. For on the sun the continuous eruption of matter from below the photosphere would sufficiently mix the gaseous matter by transfer in mass, if we could conceive of it as not mixed by diffusion. Any apparent stratification can only be due to some vapours continuing incandescent at lower temperatures than others.—A. C. RANYARD.

considerably from the results obtained by other observers. The mean of seven other fairly accordant determinations of the parallax of Vega would give its intrinsic light-giving power as 1·92. In any case the two stars are evidently exceptional, and, as what we are seeking for is an average result, may well be left on one side, and then the remaining stars do not differ extravagantly in brightness. The mean Sirian star would then have a light-giving power of 1·07; the mean Solar star of 1·8; a result which I think may at least warrant us in saying that the supposed superiority of First Type stars receives no support from it.

Yet another mode of attacking the problem is open to us. Binary stars, the orbits of which have been determined afford a means, as Mr. Monck has pointed out, of forming some idea of their relative brightness, if we assume that all the stars in question are spheres of equal density, and Mr. Gore, in his recent "Catalogue of Binary Stars," has computed this relative brilliancy per unit of surface for most of the fifty-nine stars whose orbits he gives. The result is a curious one. All the stars are, as Mr. Gore himself remarks, either First or Second Type, and there is a well-marked and unmistakable superiority of the First over the Second.* Assuming all the stars of equal density, the Sirian are about six times as bright, surface for surface, as the Solar. From this we may infer that the slight superiority in total radiating power of the Solar stars is not due to greater extent of photosphere in proportion to their mass, but that the very reverse is the case; so that the Solar stars do not merely emit more light than the Sirian, but they are superior to them in a yet higher proportion, both in size and density. If so, we may regard theorists as probably right when they have placed the Second Type stars as belonging to a later stage that the First; but as wrong when they have regarded the Sirian stars as occupying the apex of the curve, and stars like our sun as being well advanced on the road to decay.

* Except in the case of one star, γ Leonis, which is clearly by far the brightest star, surface for surface, on the assumption mentioned above.

A PERPETUAL CALENDAR.

In addition to the rules given in the last number for finding the day of the week corresponding to any given date New Style, we might have added some simple rules to extend the use of Mr. Prince's table and calendar to dates previous to 2nd September 1752, when the Old Style of reckoning came to an end. The change of style was effected in England by dropping the eleven days between Wednesday the 2nd September 1752, and Thursday the 14th September 1752. If the eleven days had not been dropped, the 14th of September would have been on a Monday; therefore, in passing backwards from New Style dates to Old Style dates, Thursday becomes Monday and one jumps forward four days in the week, or backwards three days.

To find the day of the week on which an event happened in the last century after the change of style, the rule given in the last number was—find the day of the week for the corresponding day in this century, and go forward two days in the week. From the beginning of the century to the 2nd September 1752, you must find the day of the week for the corresponding day in this century and go forward six days, which is equivalent to going back one day in the week.

Events which happened in the 17th century occurred on the same day of the week as that on which the bicentenary of the event falls in this century; thus, Evelyn mentions that Ash Wednesday in the year 1661 was on February 27th. Turning to the table in the last number, we find that the Dominical Letter for 1861 was F, and that the 27th February 1861 was also on a Wednesday. To go back to preceding centuries of Old Style reckoning we go forward one day in the week for every century. Thus, events in the 16th century which happened on a Sunday, have their tercentenaries in this century on a Saturday.

Mr. E. Erskine Scott has sent us a Perpetual Almanack and Calendar published by him in 1850, which, besides a table for finding the day of the week corresponding to any day of the year when the Dominical Letter is given, gives a table with the Dominical Letter for every year, from the Christian Era onwards, reckoning by either Old Style or New—a table which will be found convenient for determining the days of the week corresponding to dates in foreign countries as well as in England. The Gregorian or New Style was adopted in Rome in 1582; in Paris, by taking ten days off the Calendar, 15th December 1582. In Russia, Old Style is still in use. It now differs from the New Style by twelve days; thus, the 13th of April 1891 in England corresponds to the 1st of April in Russia.

TABLE I.

Mr. Erskine Scott's Table for finding the Dominical Letter or Letters for any Year, Old Style or New.

New Style. Hunds. of Years.				Years above Hundreds.				Old Style. Hundreds of Years.						
100	200	300	400											
500	600	700	800											
900	1000	1100	1200					...	100	200	300	400	500	600
1300	1400	1500	1600					700	800	900	1000	1100	1200	1300
1700	1800	1900	2000					1400	1500	1600	1700	1800	1900	2000
2100	2200	2300	2400					2100	2200	2300	2400	2500	2600	2700
C	E	G	BA					DC	ED	FE	GF	AG	BA	CB
B	D	F	G	1	29	57	85	B	C	D	E	F	G	A
A	C	E	F	2	30	58	86	A	B	C	D	E	F	G
G	B	D	E	3	31	59	87	G	A	B	C	D	E	F
FE	AG	CB	DC	4	32	60	88	FE	GF	AG	BA	CB	DC	ED
D	F	A	B	5	33	61	89	D	E	F	G	A	B	C
C	E	G	A	6	34	62	90	C	D	E	F	G	A	B
B	D	F	G	7	35	63	91	B	C	D	E	F	G	A
AG	CB	ED	FE	8	36	64	92	AG	BA	CB	DC	ED	FE	GF
F	A	C	D	9	37	65	93	F	G	A	B	C	D	E
E	G	B	C	10	38	66	94	E	F	G	A	B	C	D
D	F	A	B	11	39	67	95	D	E	F	G	A	B	C
CB	ED	GF	AG	12	40	68	96	CB	DC	ED	FE	GF	AG	BA
A	C	E	F	13	41	69	97	A	B	C	D	E	F	G
G	B	D	E	14	42	70	98	G	A	B	C	D	E	F
F	A	C	D	15	43	71	99	F	G	A	B	C	D	E
ED	GF	BA	CB	16	44	72	.	ED	FE	GF	AG	BA	CB	DC
C	E	G	A	17	45	73	...	C	D	E	F	G	A	B
B	D	F	G	18	46	74	...	B	C	D	E	F	G	A
A	C	E	F	19	47	75	.	A	B	C	D	E	F	G
GF	BA	DC	ED	20	48	76	...	GF	AG	BA	CB	DC	ED	FE
E	G	B	C	21	49	77	.	E	F	G	A	B	C	D
D	F	A	B	22	50	78	.	D	E	F	G	A	B	C
C	E	G	A	23	51	79	.	C	D	E	F	G	A	B
BA	DC	FE	GF	24	52	80	.	BA	CB	DC	ED	FE	GF	AG
G	B	D	E	25	53	81	.	G	A	B	C	D	E	F
F	A	C	D	26	54	82		F	G	A	B	C	D	E
E	G	B	C	27	55	83	.	E	F	G	A	B	C	D
DC	FE	AG	BA	28	56	84	.	DC	ED	FE	GF	AG	BA	CB

Directions.—Look for the hundreds contained in the given year at the top of the Table, on the left for New

Style, and on the right for Old Style; then below this point, and on a line with the given year of the century in the centre of the Table, you will find the Dominical Letter for the year.

TABLE II.

For Finding the Days of the Week corresponding to the Days of the Months; the Dominical Letter for the Year being ascertained by Table I.

Note.—*The double letters in each compartment refer to leap years, the single to common years.*

JANUARY					A AG	B BA	C CB	D DC	E ED	F FE	G GF
FEBRUARY					D DC	E ED	F FE	G GF	A AG	B BA	C CB
MARCH					D ED	E FE	F GF	G AG	A BA	B CB	C DC
APRIL					G AG	A BA	B CB	C DC	D ED	E FE	F GF
MAY					B CB	C DC	D ED	E FE	F GF	G AG	A BA
JUNE					E FE	F GF	G AG	A BA	B CB	C DC	D ED
JULY					G AG	A BA	B CB	C DC	D ED	E FE	F GF
AUGUST					C DC	D ED	E FE	F GF	G AG	A BA	B CB
SEPTEMBER					F GF	G AG	A BA	B CB	C DC	D ED	E FE
OCTOBER					A BA	B CB	C DC	D ED	E FE	F GF	G AG
NOVEMBER					D ED	E FE	F GF	G AG	A BA	B CB	C DC
DECEMBER					F GF	G AG	A BA	B CB	C DC	D ED	E FE
1	8	15	22	29	Sun.	Sat.	Fri.	Thur.	Wed.	Tues.	Mon.
2	9	16	23	30	Mon.	Sun.	Sat.	Fri.	Thur.	Wed.	Tues.
3	10	17	24	31	Tues.	Mon.	Sun.	Sat.	Fri.	Thur.	Wed.
4	11	18	25	...	Wed.	Tues.	Mon.	Sun.	Sat.	Fri.	Thur.
5	12	19	26		Thur.	Wed.	Tues.	Mon.	Sun.	Sat.	Fri.
6	13	20	27	...	Fri.	Thur.	Wed.	Tues.	Mon.	Sun.	Sat.
7	14	21	28	...	Sat.	Fri.	Thur.	Wed.	Tues.	Mon.	Sun.

Directions.—The Dominical Letter answering to the given year being found by Table I., find this Dominical Letter in the above Table on the same horizontal line with the given month, and under it, in the lower part of the Table, are the days of the week, corresponding with the days of the given month in the same horizontal line on the left-hand side of the Table.

ERRATUM.

In the Article on the Milky Way in the Southern Hemisphere, in the last number of Knowledge, it was by mistake stated that one of the two clusters at the bottom of Mr. Barnard's plate of the Sagittarius Region of the Milky Way was entirely wanting in Mr. Russell's photographs. This is not the case, though there is ample evidence of the variation in brightness of many other stars shown upon the plates. Only one of the clusters is shown in the plate from Mr. Russell's photograph; the other, or preceding cluster, is just outside the field.

OUR INVISIBLE FOES, OR BACTERIA IN AGRICULTURE.

By Miss A. W. Buckland.

THE first question now asked whenever an epidemic attacks either man or the lower animals is, Is it caused by germs or *bacilli* floating in the air, or conveyed by water, milk, or any other medium. The germ theory of disease, at present so popular, may be said to have originated in the successful experiments made by M. Pasteur for the cure of the dreadful disease known as splenic fever in sheep, and the importance of the subject to the agriculturist and merchant, as well as to the medical profession, may be best understood and appreciated by reference to a few facts.

During the year 1888 more than eleven hundred head of cattle were slaughtered in Dublin, because they had been in contact with a few suffering from pleuro-pneumonia, whilst the Commission appointed to investigate the best mode of preventing and curing this and similar diseases, recommended the continuous slaughter of all animals which might have been exposed to infection, adding to the report, however, a clause to the effect that, should experiments in inoculation be deemed advisable, such experiments should be carried out only with the most stringent precautions.

Meanwhile the Government of India, as the result of experiments made, has ordered the inoculation of all the valuable elephants in the Government stables, for the prevention of a disease by which they have hitherto been decimated. M. Pasteur, as is well known, proposed to exterminate the millions of rabbits which have become such a pest in Australia and New Zealand, by introducing among them by inoculation the disease known as chicken-cholera, deadly to fowls and rabbits, but harmless to other animals and to man. But although the Australasian Governments approached the matter in a scientific spirit, and gave every facility for properly conducted experiments, under the supervision of Dr. Katz, bacteriologist, employed by the Linnean Society,—(1) to test the communicability of chicken-cholera to rabbits, the possibility of spreading the disease from rabbit to rabbit, and the readiness and channels by which such communication could be procured; (2) to ascertain whether the disease is transmissible from infected rabbits to other domestic animals—mammals and birds; (3) to ascertain whether the infectivity of the disease is weakened by repeated transmissions from rabbit to rabbit,—the experiments do not appear to have been successful, for although the rabbits inoculated die, they do not apparently convey the disease to others. Nevertheless it seems to be demonstrated beyond dispute, that certain forms of bacteria invariably accompany certain diseases, and reproduce similar diseases when introduced by inoculation into the bodies of men or animals.

These *micro-organisms*, so exceedingly small as to be absolutely invisible to the naked eye, have yet been so carefully observed microscopically, and so faithfully reproduced and enlarged by photography, that they can be studied in all their wonderfully varied forms; and the differences between them are sufficiently marked to be appreciated even by the non-scientific observer. Some resemble dots in various groups; some are twisted spirals; some look like chains; others resemble small bags, with strings attached; some look like branches of trees, whilst others are simply rods crossing each other.

If we regard them as animals, they do not appear to possess any bodily parts, neither head nor tail, neither heart nor stomach; whilst if they are vegetables, they have neither roots nor branches, although abounding in spores. That they are very much alive cannot be doubted, nor the fact that they multiply with the most astonishing rapidity. The growth of one which occurs in sugar is so rapid that 49 hectolitres of molasses were converted into a gelatinous mass in twelve hours.

Micro-organisms can be cultivated in various media, and will still retain their identity, but they cannot all be cultivated in the same media. Dr. Crookshank says: "Some species cannot be cultivated artificially, others will only grow upon blood-serum; many grow upon nutrient gelatine, but some species only if it be acid or alkaline

respectively. Though the comma bacillus of Koch, like the majority of organisms, grows best on an alkaline medium, yet the surface of a potato is acid, and on this it is well known to flourish at the temperature of the blood."

These bacteria are everywhere, in the air we breathe, in the water we drink, in the ground we tread on, but happily some are innocuous; and the noxious must find a suitable soil in which to develop their evil nature, otherwise the human race must have been exterminated by them long ago, and the whole of the animal and vegetable world must have become simply putrefactive media for the propagation of micro-organisms. We cannot pretend in this article to go into any scientific description of the numerous bacteria which, thanks to the researches of Koch, Pasteur, and many other zealous workers on the Continent, have become as well known as creatures of larger growth; but we will endeavour to point out some of the points of interest to the general public in this new science, as brought before us in the *Manual of Bacteriology* of Dr. Crookshank, one of our chief English workers in this branch of science, who established a bacteriological laboratory at King's College, in which many elaborate investigations are carried on daily. His *Manual* is primarily for the use of students, and therefore deals largely with the methods of cultivation, and preparation for the microscope, of the various species of bacteria, all the necessary apparatus being elaborately illustrated.

The study of bacteria may be considered to be quite recent, yet, as Dr. Crookshank points out, "Leeuwenhoeck, two hundred years ago, recognised and described microscopic organisms in putrid water and saliva, which probably correspond with organisms such as vibrios and leptothrix of modern times." The article upon "Medicine" in the *Encyclopædia Britannica* also points out that Schönlein "made in 1839 one discovery apparently small, but in reality most suggestive, namely, that the contagious disease of the head called *favus* is produced by the growth in the hair of a parasitic fungus." In this may be found the germ of the startling modern discoveries in parasitic diseases; and it seems that even as early as 1773 Müller suggested a classification of these microscopic organisms; but even to the present day their exact place in the economy of nature has not been determined. "Existing as they do," says Dr. Crookshank, "upon the very borderland of the vegetable and animal kingdoms, not only have they been transferred from one to the other, but even the question has been raised whether the smaller forms should be considered as living beings at all." But he says: "The gradual improvements in the means of studying such minute objects, the methods of cultivating them artificially, and of studying their chemistry and physiology, and the ever-increasing revelations of the microscope, have resulted in establishing these microscopic objects as members of the vegetable kingdom, ranking among the lowest forms of fungi."

After showing the various classifications of these fission-fungi, Dr. Crookshank divides them, after Zopf, into four groups, and each group again into genera and species. He then gives a long list of each, classifying them according to their association with disease in man and animals, and adding to the list such as are unassociated with disease. Glancing at these lists, we are struck by the fact that in some of the groups almost all the species are associated with disease, whilst some forms are common to men and animals. In *Streptococcus*, for instance, there are seventeen species traceable to disease in man, eleven belonging to disease in animals, two common to animals and man, and only four unassociated with disease. In *Sarcina*, on the contrary, all the species appear to be innocuous. In other groups the hurtful and innocent species are more equally divided. In the genus *Micrococcus*, to which belongs the much-dreaded germ of rabies, and also that of scarlatina, measles, and whooping-cough, there are ten species belonging to human disease, five to animals, one to plants, and eighteen which are harmless. In the Bacteriaceæ the hurtful and innocent species seem also to be pretty equally divided; but to this group belong some of the most dreaded of disease-germs, such as that of pneumonia, diphtheria, chicken-cholera, the disputed comma bacillus of Asiatic cholera, the bacilli associated with typhus fever, with anthrax, with tuberculosis, with malaria, with swine fever, &c. &c.

The yeast-fungi and mould-fungi, some of which are so destructive to vegetable life, appear to be allied to the bacteria or fission-fungi, but are nevertheless quite distinct. The moulds of various kinds, which form on almost everything eatable, especially in damp weather, belong to these, but they also include the potato-blight (*Peronospora infestans*), grape-disease (*Oidium*), the mildew, smut, and other wheat-diseases, the salmon-fungus, and the silkworm disease; all of which have had disastrous effects upon the prosperity of mankind, although they have not been inimical to human life in the same way as the Bacteria.

It would seem as though these micro-organisms were Nature's favoured weapons of destruction—her tiny poisoned arrows, with which she shoots hither and thither continuously, and against which all living things, whether animal or vegetable, require to be rendered more invulnerable than Achilles. Is there to be found any Styx wherein mankind *may* be rendered invulnerable to the attacks of these invisible foes? Pasteur is supposed to have discovered the means of depriving some of these arrows of their deadly power by extending to other diseases the system of inoculation, introduced first in connection with small-pox, and afterwards modified by Jenner into vaccination, long before the discovery of Bacteria as the constant accompaniment, if not the actual source, of disease.

The two diseases, with the cure or prevention of which the name of Pasteur will be always associated, are rabies or hydrophobia, and anthrax, known also as splenic fever or wool-sorter's disease; the former is, without doubt, one of the most terrible of maladies, and the latter, although less generally known, has caused the cruel death of multitudes who have been brought into contact with it. Both diseases are communicated in the first place from animals to man. The mode of prevention adopted by M. Pasteur is inoculation with the bacillus of the disease, thus resembling the old inoculation for small-pox rather than vaccination, which is the communication of an allied animal disease rather than the human form of that disease. But M. Pasteur does not, as in the old inoculation, give the disease in its full force; but he takes the bacillus, cultivates it in different media, and only introduces it into the animal or human body after it has been attenuated and its full malignity destroyed.

Speaking of anthrax, Dr. Crookshank says: "By cultivating the bacillus in neutralized bouillon at 42°–43° C. for about twenty days, the infecting power is weakened, and animals inoculated with it are protected against the disease." To obtain a still more perfect immunity, they are inoculated a second time with material which has been less weakened. The animals are then protected against the most virulent anthrax, but *only for a time*. From such a culture, however, new cultures of virulent bacilli can be started, and a culture that is "vaccin" for

sheep, kills a guinea-pig, and then yields bacilli that are fatal to sheep. Exposure to a temperature of 55° C., or treatment with ·5 to 1 per cent. carbolic acid, deprives the bacilli of their virulence. The virulence of the bacillus is also altered by passing the bacillus through different species of animals. The bacillus of sheep or cattle is fatal when re-inoculated into sheep or cattle; but, if inoculated in mice, the bacilli then obtained lose their virulence for sheep or cattle; only a transitory illness results, and the animals are protected for a time against virulent anthrax. The possibility of mitigating the virus depends upon the species of animal; rodents cannot be rendered immune by any known "vaccin." The same process is employed by M. Pasteur in his now celebrated inoculations for hydrophobia. In the course of his experiments some very curious facts have come to light; it has been discovered that "passing the virus through various animals considerably modifies its properties. By inoculating a monkey from a rabid dog, and then passing the virus through other monkeys, the virulence is diminished; but by inoculating a rabbit from the dog, and passing the virus from rabbit to rabbit, the virulence is increased." In swine-erysipelas Pasteur and Thuillier discovered that "by passing the virus through pigeons the virulence was increased, but by passing it through rabbits it was progressively diminished. Thus a virus was obtained from a rabbit, which produced only a mild disease in pigs, and after recovery complete immunity."

To the non-professional observer, these facts seem pregnant with deep meaning; they appear to point to the change from the old inoculation for small-pox to the vaccination of Jenner, in which a similar but less virulent disease may be communicated from a lower animal to man, producing immunity from the graver disease; and as we look down the long lists of bacilli, some of deadly virulence and some innocuous, yet all belonging to the same group of germs, we wonder whether eventually it may not be found that a cultivation of innocent germs may be made to supplant the more malignant forms; and this opens up the whole question of immunity, which forms one of the most interesting portions of Dr. Crookshank's book.

Immunity may be natural or acquired. We all know that certain individuals are much more subject to infectious diseases than others, even of the same family. In some diseases one attack renders the person impervious to the same disease; but this is not always the case, sometimes after a time the protective influence of the first attack ceases, and the individual succumbs to the disease a second time. In certain diseases one attack predisposes to a recurrence of the disease, as for example erysipelas; and again, "the occurrence of one disease is stated to induce a liability to others; small-pox and typhoid fever are regarded as predisposing to tuberculosis." When Pasteur first began to try to mitigate the virulence of anthrax, he found that by cultivating the microbe in chicken broth, and allowing it to remain for several months before carrying on successive cultivations in fresh media, "the new generations which were then obtained were found to have diminished in virulence, and ultimately a virus was obtained which produced only a slight disorder; and on recovery the animal was found to be proof against inoculation by virulent matter." This change in the quality of the virus M. Pasteur attributed to a prolonged contact with the oxygen of the air, and he shows that if the cultivation of these germs is carried on in sealed tubes, admitting very little air, the virulence is retained. Heat also has been found to diminish the virulence of the bacillus of anthrax, and the same has been brought about by chemical means, carbolic acid in minute quantities, and bichromate of potash added to a cultivation, "gave after three days a new growth, which killed rabbits, guinea-pigs, and half the sheep inoculated; after ten days rabbits and guinea-pigs, but not sheep; and after a longer time even guinea-pigs were unaffected."

In discussing the question of what constitutes immunity, Dr. Crookshank gives some very curious and suggestive facts. He says: "Raulin has shown that *Aspergillus niger* develops a substance which is prejudicial to its own growth in the absence of iron salts in the nutrient soil. Pasteur has suggested that in rabies, side by side with the living and organized substance, there is some other substance which has, as in Raulin's experiment, the power of arresting the growth of the first substance. If we accept the theory of arrest by some chemical substance, we must suppose that in the acquired immunity afforded by one attack of an infectious disease this chemical substance is secreted, and, remaining in the system, opposes the onset of the micro-organism at a future time. In the natural immunity of certain species and individuals we must suppose that this chemical substance is normally present."

Passing over two other theories, each of which presents certain difficulties, we find the curious fact that in some cases the white blood-cells appear to have the singular power of destroying bacteria. "If anthrax bacilli are inoculated in the frog, the white blood-cells (leucocytes) are observed to incorporate and destroy them until they entirely disappear, and the animal is not affected. But if the animal, after inoculation, is kept at a high temperature, the bacilli increase so rapidly that they gain the upper hand over the leucocytes, and the animal succumbs. In septicæmia of mice the white blood-cells are attacked and disintegrated by the bacilli in a similar way. It is, however," adds Dr. Crookshank, "difficult to accept any explanation of immunity from these observations—to suppose, for example, that immunity depends upon the micro-organisms being unable to cope with the leucocytes in certain species. It is difficult to conceive that the leucocytes in the blood and tissues in the field-mouse are differently constituted from those in the house-mouse, so that they form an effectual barrier in the one case, though so readily destroyed in the other." Hence we understand that field-mice are exempt from the septicæmia which is fatal to house-mice and sparrows, the representative bacilli of the disease being found most commonly in the interior of the white blood-corpuscles. Perhaps the immunity of field-mice may result from some chemical secretion or the difference in their mode of life and in their food. This is a subject still open to investigation.

In anthrax "a drop of blood from an affected animal, or a minute portion of a cultivation, introduced under the skin of a mouse or guinea-pig, causes its death, as a rule, in from twenty-four to forty-eight hours. Sheep fed upon potatoes which have been the medium for cultivating the bacillus, die in a few days. Goats, hedgehogs, sparrows, cows, horses are all susceptible. Rats are infected with difficulty. Pigs, dogs, cats, white rats, and Algerian sheep have an immunity from the disease. Frogs and fish have been rendered susceptible by raising the temperature of the water in which they lived." In this list we find the same difference with regard to sheep as in the two species of mice. To the common sheep the disease is fatal, whilst the Algerian sheep is immune. This immunity of certain species has been seized upon by agriculturists, who, when their flocks and herds suffer from a certain disease, have found it beneficial to change the breed. At the Cape of Good Hope, for instance, many

years ago, when the Angora goat was introduced, it was found to be less liable to scab than the common goat. The same thing has followed from great blights in the vegetable world. The disastrous potato-blight caused the introduction of many new varieties found by experience to be capable of resisting the disease; and the European vines affected by phylloxera are now being replaced by different kinds brought from America and other parts of the world. There can be no doubt that in time this immunity will cease, and the newly introduced variety will require to be again replaced, unless some means should be found of destroying the micro-organisms, which, like the newly introduced animals or vegetables, will in time adapt themselves to their surroundings, and perhaps acquire fresh virulence thereby.

When the investigations into disease-germs began, it was thought by many that all infective diseases might be prevented by inoculation, but at present the various experiments made have not confirmed this idea except in anthrax, or splenic fever, rabies, and the new remedy for tuberculosis*; it seems, however, probable that some day pleuro-pneumonia may be added to the list. For many years past this disease has been successfully treated at the Cape of Good Hope, and in Australia, by inoculation.

Happily, it seems that the wide-spread infection, which at one time was supposed to be likely to follow the burial of an infected animal through earth-worms bringing the bacilli to the surface, is not so common as was believed. "Klein has pointed out that if mice and guinea-pigs which have died of anthrax are kept unopened, the bacilli simply degenerate and ultimately disappear"; therefore Dr. Crookshank thinks that free access to oxygen is necessary to develop the spores. "Contamination of ground in which diseased animals have been buried must result, therefore, from bodies in which a post-mortem examination has been made, by which the blood and organs have been freely exposed to the air, or from animals which have not been examined, owing to their hides being soiled with excretions, and with blood which issues from the mouth and nostrils before death."

One of the most prominent uses of the science of bacteriology is the power gained by it of examining the water, air, and soil of any place, and thus determining the number and character of the bacteria in any given spot. By this means, places particularly subject to any given disease may be avoided by those peculiarly liable to such disease, and it may be, also, that eventually a means may be found of destroying the pestilential bacilli, and rendering spots formerly unhealthy fit for human habitation.

Before concluding this paper, we ought to point out the numbers of bacteria which have been observed to be present in the air at different times and places. Miquel, who has made this a special study, finds "the average number per cubic metre of air for the autumn quarter at Montsouris to be 142, winter quarter 49, spring quarter 85, and summer quarter 105. In air collected 2,000 to 4,000 metres above sea-level, not a single bacterium or fungus spore was furnished; while in ten cubic metres of air from the Rue de Rivoli (Paris), the number was computed at 55,000. By an apparatus known as 'Hesse's,' twenty-five litres of air from an open square in Berlin, gave rise to three colonies of bacteria and sixteen moulds; whilst two litres from a schoolroom just vacated by the scholars, gave thirty-seven colonies of bacteria and thirty-three moulds." The wonder is that with all these sources of disease and death constantly with us, anyone should escape; nevertheless, it is an established fact that none of these micro-organisms are ever found in perfectly healthy blood. The reason of this is not plain. It is certain that the healthy and unhealthy alike must inhale or swallow these germs; why should they be deadly to the one and innocuous to the other? Is it because in health the white corpuscles of the blood are in such a state of chemical activity as to be able to absorb and consume these micro-organisms, as in the recorded case of the frog? And is it, as in the same case, only when the temperature becomes raised by fever, that the germs develop too rapidly for natural elimination? This would appear a possible explanation, but more is wanted. Why, if these germs are everywhere, should we not more frequently hear of the spontaneous outbreak of disease, instead of finding it generally traceable to one especial source?

* Dr. Koch's inoculation differs from that of Pasteur in the injection of dead instead of living bacilli.

THE FACE OF THE SKY FOR APRIL.

By Herbert Sadler, F.R.A.S.

The number of sun-spots and faculæ on the solar disc continues steadily to increase. The zodiacal light should be looked for during the first ten days of the month. Conveniently observable minima of Algol occur at 7h. 14m. P.M. on the 4th; 0h. 7m. A.M. on the 22nd; and 8h. 56m P.M. on the 24th. The following are the times of minima of some of the Algol type variables alluded to by Miss Clerke in the March number of Knowledge, and which may be conveniently observed at the present time. The places are for 1890.

U Cephei (0h. 52m. 32s. +81° 17′). Max. 7·1 mag.; min. 9·2 mag. Period, 2d. 11h. 49m. 45s. April 14th, 1h. 53m. A.M.; April 19th, 1h. 32m. A.M.; April 24th, 1h. 12m. A.M.; April 29th, 0h. 52m. A.M.

R Canis Maj. (7h. 14m. 30s. −16° 11′). Max. 5·9 mag.; min. 6·7 mag. Period, 1d. 3h. 15m. 55s. April 2nd, 6h. 49m. P.M.; April 3rd, 10h. 5m. P.M.; April 19th, 7h. 46m. P.M.; April 28th, 9h. 52m. P.M.

S Cancri (8h. 37m. 39s. +19° 26′). Max. 8·2 mag.; min. 9·8 mag. Period, 9d. 11h. 37m. 45s. April 19th, 0h. 36m. A.M.

δ Libræ (14h. 55m. 6s. −8° 5′). Max. 5·0 mag.; min. 6·2 mag. Period, 2d. 7h. 51m. 23s. April 2nd, 8h. 53m. P.M.; April 9th, 8h. 28m. P.M.; April 16th, 8h. 1m. P.M.; April 23rd, 7h. 36m. P.M.; April 30th, 7h. 12m. P.M.

U Coronæ (15h. 13m. 43s. +32° 3′). Max. 7·5 mag.; min. 8·9 mag. Period, 3d. 10h. 51m. 8½s. April 6th, 1h. 5m. A.M.; April 12th, 10h. 47m. P.M.; April 19th, 8h. 29m. P.M.

A maximum of S Coronæ (6·1 mag.—7·8 mag. at max.; 11·9 mag. −12·5 mag. at min.), which follows U Coronæ 3m. 12s. in R.A., and is 17′·3 south of it, is due on April 5th.

Mercury is very well placed for observation during the greater part of April. On the 1st he sets at 7h. 22m. P.M., or 52m. after the sun, with an apparent diameter of 5½″ and a northern declination of 8° 2′. At this time he will appear about as bright as Aldebaran, about $\frac{93}{100}$ of the disc being illuminated. He gradually increases in brightness, setting on the 7th at 8h. 9m. P.M., 1h. 29m. after the sun, with an apparent diameter of 6″, and a northern declination of 13° 20′. At this time he is considerably brighter than an average first magnitude star in the same position, rather less than eight-tenths of the disc being illuminated. On the 11th he sets at 8h. 37m. P.M., 1h. 50m. after the sun, with an apparent diameter of 6½″, and a

northern declination of 16° 18′. His theoretical brightness is now about equal to what it was on the 1st, but, owing to his being considerably farther from the sun, he will probably appear brighter. About $\frac{64}{100}$ of the disc is now in sunlight. On the 17th he sets at 9h. 3m. p.m., 2h. 6m. after the sun, with an apparent diameter of $7\frac{1}{2}''$, and a northern declination of 19° 28′. He is at his greatest eastern elongation (19° 50′) at 7h. p.m. on the 18th. On the 21st he sets at 9h. 10m. p.m., 2h. 7m. after the sun, with an apparent diameter of 8·4″, and a northern declination of 20° 40′. He has now decreased very perceptibly in brightness, about three-tenths of the disc being illuminated. On the 27th he sets at 9h. 1m. p.m., 1h. 46m. after the sun, with an apparent diameter of $9\frac{3}{4}''$, and a northern declination of 21° 5′. He now does not exceed a 5th magnitude star in brightness, about $\frac{15}{100}$ of the disc being illuminated. During the month Mercury passes through Pisces on to the borders of Aries and Taurus, being found at the end of the month near the group ζ, τ, 63 and 65 Arietis, but without approaching any conspicuous star very nearly.

Venus is a morning star throughout the month, but is too near the sun to be well seen. On the first she rises at 4h. 27m. a.m., 1h. 11m. before the sun, with an apparent diameter of 16·0″, and a southern declination of 11° 36′, She is near Jupiter on the mornings of the 7th and 8th. On the 30th she rises at 3h. 39m. a.m., 57m. before the sun, with an apparent diameter of $13\frac{1}{2}''$, and a southern declination of 0° 2′. About seven-tenths of the disc is illuminated on the 1st of April, and nearly eight-tenths on the 30th, when the theoretical brightness of the planet is only one-third of what it was at the beginning of January. On the morning of the 15th Venus will be very near the 4th magnitude star ϕ Aquarii. During the month she moves from Capricornus through the greater part of Aquarius.

Both Mars and Jupiter are invisible for the purposes of the amateur observer. Saturn is well placed for observation, rising on the 1st at 3h. 17m. p.m., and setting at 5h. 3m. a.m., with a northern declination of 9° $10\frac{1}{2}'$, and an apparent equatorial diameter of $19\frac{1}{4}''$ (the major axis of the ring system being $44\frac{1}{4}''$, and the minor $3\frac{3}{4}''$). On the 30th he rises at 1h. 24m. p.m., and sets at 3h. 14m. a.m., with a northern declination of 9° 37′, and an apparent equatorial diameter of $18\frac{1}{2}''$ (the major axis of the ring system being $42\frac{1}{2}''$, and the minor 4·0″). Shortly before 8 p.m. on the 3rd Titan is 17″ south of the planet; and on the evening of the 5th Iapetus will be about 45″ *n* a little *p* Saturn. Early on the evening of the 17th Titan will be seen about 20″ south of Saturn, and on the 22nd and 23rd Iapetus is near its western elongation, and at its brightest. Shortly before Saturn sets on the 30th a 9·5 magnitude star will be seen about 70″ north of the planet. During April Saturn describes a short retrograde path in Leo, but he does not approach any naked-eye star. Uranus is an evening star, rising on the 1st at 8h. 5m. p.m., with an apparent diameter of $3\frac{3}{4}''$, and a southern declination of 11° 0′. On the 30th he rises at 6h. 4m. p.m., with a southern declination of 10° 33′. He describes a short retrograde path to the E.N.E. of 86 Virginis. He is in opposition on the 19th, when he is about $1{,}623\frac{1}{2}$ millions of miles distant from the earth. A map of his path up to the beginning of September will be found in the *English Mechanic* for February 6th, 1891. Neptune is, for all practical purposes, invisible.

Shooting stars are fairly plentiful in April, the most marked shower being that of the Lyrids, with a radiant point in 18h. 0m. R.A. and +33° decl. The radiant point rises on the nights of the 19th and 20th, when the maximum occurs, at 6h. 27m. p.m., and souths at 4h. 8m. a.m.

The moon enters her last quarter at 6h. 30m. a.m. on the 2nd; is new at 8h. 57m. p.m. on the 8th; enters her first quarter at 1h. 40m. a.m. on the 16th; and is full at 5h. 5m. a.m. on the 23rd. She is in perigee at 10h. a.m. on the 7th (distance from the earth 223,850 miles), and in apogee at 11h. 30m. a.m. on the 19th (distance from the earth 251,920 miles). The greatest western libration is at 4h. 54m. a.m. on the 13th, and the greatest eastern at 5h. 44m. p.m. on the 27th.

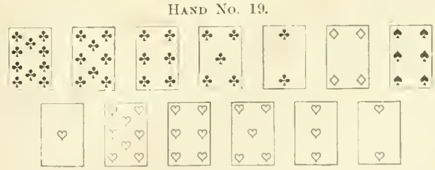
Whist Column.

By W. Montagu Gattie, B.A.Oxon.

The Management of Trumps.

We believe it was the late James Clay who once facetiously remarked that there were twenty thousand young men going about in rags in America because they would not lead trumps from five to an honour. There are, nevertheless, many cases in which it is desirable to play a waiting game, even though favoured by fortune with great strength in trumps. A curious instance of the success of Fabian tactics is furnished by Hand No. 16 (Knowledge for December last), in which the original leader persistently avoids leading trumps, although holding six to two honours. Such cases are for the most part peculiar, and scarcely admit of generalisation; but perhaps it may safely be laid down that, when the leader's score is 4, he should almost always hesitate to open trumps unless he holds winning cards in the plain suits. A typical case is that in which the hand contains, besides the trumps, *numerical strength only* in one of the plain suits, so that two or even three rounds will probably be required in order to establish it. The advantage, under such circumstances, of opening the plain suit in the first instance, is well illustrated by the following hand, for which we are indebted to Mr F. S. Hughes:—

Hand No. 19.



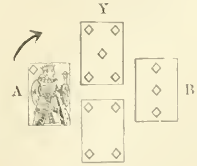
Z's Hand.

Score—AB, 2; YZ, 4.

Z turns up the six of hearts.

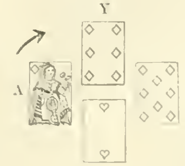
Note.—A and B are partners against Y and Z. A has the first lead; Z is the dealer. The card of the leader to each trick is indicated by an arrow.

Trick 1.



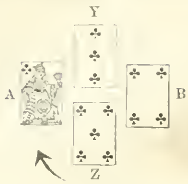
Tricks—AB, 1; YZ, 0.

Trick 2.



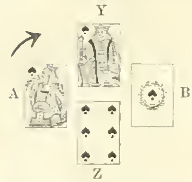
Tricks—AB, 1; YZ, 1.

Trick 3.



Tricks—AB, 2; YZ, 1.

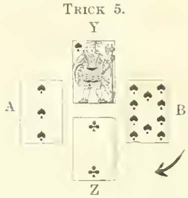
Trick 4.



Tricks—AB, 3; YZ, 1.

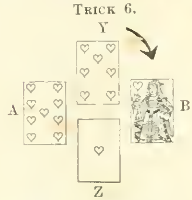
Note.—*Trick* 3.—YZ being at the score of 4, Z determines not to open trumps, and leads his fourth-best club.

Trick 5.



Tricks—AB, 3; YZ, 2.

Trick 6.

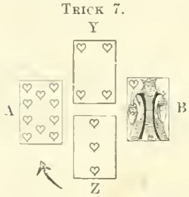


Tricks—AB, 3; YZ, 3

Note.—*Trick* 5.—Z's discard shows five clubs originally, and enables his partner to count his hand.

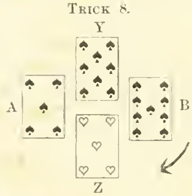
Trick 6.—The four of trumps is now marked in Y's hand, and the three best trumps clearly lie between A and B.

Trick 7.



Tricks—AB, 4; YZ, 3.

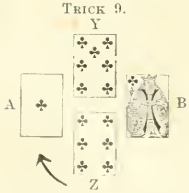
Trick 8.



Tricks—AB, 4; YZ, 4.

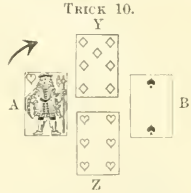
Note.—*Trick* 7.—Z therefore continues the trumps; for, if the adverse trumps are all in one hand, AB must win the game in any case, since they will make three tricks in trumps, and one, at least, in clubs. Accordingly, Z plays on the assumption that the adverse trumps are divided. As the cards happen to lie, he would win the game equally by continuing the club suit; but this would be dangerous, as AB might be enabled to make their trumps separately.

Trick 9.



Tricks—AB, 5; YZ, 4.

Trick 10.



Tricks—AB, 6; YZ, 4.

Tricks 11 to 13.—A leads ace of diamonds, on which Z plays his last trump, and YZ then make two tricks in clubs.

YZ Score the Odd Trick and win the Game.

A's Hand	B's Hand.
H.—Kn, 10, 9.	H.—Kg, Qn.
S.—Qn, 5, 3.	S.—Ace, 10, 9, 7, 4, 2.
D.—Ace, Kg, Qn, 10, 2.	D.—Kn, 8, 3.
C.—Ace, Qn.	C.—Kg, 4.

Y's Hand.	Z's Hand.
H.—7, 4.	H.—Ace, 8, 6, 5, 3, 2.
S.—Kg, Kn, 8.	S.—6.
D.—9, 7, 6, 5.	D.—4.
C.—Kn, 9, 7, 3.	C.—10, 8, 6, 5, 2.

Remarks.—*Trick* 2.—If Z intended to lead trumps, he would trump with the five and lead the three; but for the moment he is not anxious to expose his strength.

Trick 3.—If Z leads a trump, AB make at least the odd trick. B wins with the queen, and returns the knave of diamonds. If Z ruffs and continues with the ace of trumps and then a club, A wins with the queen of clubs, and leads the knave of trumps and then the ten of diamonds; if Z ruffs and opens clubs at once, A wins with the queen, and leads the ten of diamonds and afterwards (however Z plays) the ace of diamonds; and, if Z discards his spade on trick 4, B leads the ace of spades, and Z cannot save the game. To return to the actual game, we may observe that those players who adopt the "plain-suit echo" would, in Y's place, play the seven of clubs instead of the three.

Trick 4.—Mr. Hughes remarks that "A leads a spade, and not a diamond, as he does not know whether Z is strong or weak in trumps." We think, nevertheless, that, as A has command of the clubs and some protection in spades, and as YZ are four up and Z is ruffing diamonds, the correct lead is the knave of hearts. This, however, would not save the game unless YZ played badly.

Trick 6.—Y counts three clubs and five trumps remaining in his partner's hand, and therefore leads a trump.

Trick 9.—The beginner should note that even at this point Z would lose the game by continuing the trumps instead of clearing his clubs.

Contents of No. 65.

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LONDON: MAY 1, 1891.

CONTENTS.

THE ARTIFICIAL REPRODUCTION OF RUBIES AND OTHER PRECIOUS STONES.

By Vaughan Cornish, B.Sc., F.C.S.

In speaking of the artificial reproduction of precious stones, it must be understood that we are dealing with processes which have nothing in common with the *imitation* of gems. Ingenuity and skill, and even a certain amount of scientific knowledge, have been exercised in imitating diamonds, pearls, and so forth; but the art is merely one of counterfeit, the materials produced at most deceive the eye, and they possess neither the chemical composition nor the properties of the natural objects which they simulate, except the qualities of colour and lustre. In these two points the counterfeit is often sufficiently good to deceive any save a practised eye; but it must be borne in mind that the intrinsic value of a gem, apart from the fictitious value due to rarity, depends not solely on beauty of colour and lustre, but on the hardness of the material which preserves, for instance, a cut ruby from deterioration for centuries. It is the character of permanence which gives to precious stones their pre-eminent value among other beautiful objects.

But the ruby may not only be imitated more or less successfully by colouring a dense and highly refracting kind of glass; it can also be *reproduced*, that is to say, the thing itself can be prepared in the laboratory. Such a product is termed an *artificial* ruby, and the common acceptation of the word appears to carry with it a prejudice, as if it were intended to convey that the object would be a ruby were it not that rubies are formed naturally, whereas this was produced through the intervention and contrivance of man. So much is this the case that if, as may well happen, rubies should prove to be produceable of sufficient size for the purposes of the jeweller, there will certainly be a feeling against wearing the stones so produced as ornaments, due to the idea that the jewel is in some sort a sham. This is a natural but mistaken conception. A mineral—the ruby, for instance—is a body having a certain chemical composition and other equally important characteristics, such as those of its crystalline form, specific gravity and hardness. The body is formed through the operation of certain laws of chemical combination and of crystallization. Whether the opportunity for the operation of these laws occurs in the bowels of the earth or in the crucible of the chemist, cannot be rightly held to affect the identity of the body produced.

The reproduction of minerals has been carried on for the last forty years, chiefly among a small school of French chemists, and is to be regarded as a part of the great work of chemical synthesis.

Synthetical or constructive work only begins at an advanced stage in the study of an experimental science, and the synthesis of minerals was necessarily preceded by many years of analytical investigation. In the first decade of the present century, the laws which regulate the proportions in which the elements enter into chemical combination were already established. At this time the art of chemical analysis was being rapidly developed, and its methods were applied to the examination of minerals. It was found that the elements they contained were present in those particular, definite proportions which had been found to be characteristic of chemical combination. It was during this epoch also that the laws of crystallography were first established. The chemical composition and the crystalline form were recognised as the two most essential characteristics of each mineral species, although other properties were duly taken account of, as, for instance, specific gravity, hardness and colour. Thus mineralogy was put on a sound footing as a classificatory and analytical science; but the next step in advance, the introduction of synthesis, the building up of the minerals, appeared to be beyond the power of the experimentalist. It was found that substances prepared in the laboratory, having the same chemical composition as natural minerals, did not possess their other characteristic features. Thus Heavy Spar has the same chemical composition as the sulphate of barium produced in the laboratory; but whereas the first is a hard, well-crystallized body, the second is formed as a fine powder, destitute of coherence and of crystalline form.

Again, silica occurs in nature as the well-known Rock Crystal, but in the ordinary chemical process it is obtained as a gritty powder. The silicates, a class of substances comprising many well-crystallized gems, such as the garnet, could only be reproduced artificially as *glasses*, transparent indeed and coherent, but without crystalline structure. Such failures gave rise to the impression that there was some special influence or force at work in nature in the production of minerals which could not be commanded by the chemist, just as it was supposed that the substances produced in the vegetable and animal kingdoms needed the action of the so-called *vital force*, and were incapable of reproduction in the laboratory. The belief in this *vital force* was dispelled when the advance of chemistry solved the problem of the synthesis of organic

bodies. Similarly it was found that by modifying the ordinary methods of the chemical laboratory so as to imitate more closely the conditions obtaining in the formation of rocks and of mineral veins, compounds could be produced, having not only the chemical composition, but the other characteristics of the natural minerals. For instance, in the case of barium sulphate, the material is produced in the laboratory by the interaction of a solution of a barium salt and a solution of a sulphate. It was found that if special devices were adopted so that the two solutions only came in contact with extreme slowness, the forces of crystallization came into play, and the barium sulphate separated out with the form, hardness, and other characteristics of the natural mineral. The processes previously employed had been too rough and hasty, and had not reproduced the conditions of Nature's laboratory. Water plays a part in most of the ordinary chemical processes, but under the usual conditions water cannot be raised to a temperature above 100° C., since it is then converted into steam. In the depths of the earth great pressures come into play, and when there is at the same time a high temperature, water, kept by pressure in the liquid state, acts under very special conditions. By heating silicates, such as glass, with water in strong steel vessels, so that a high temperature and great pressure are obtained, it is found that the silica is separated in the form of quartz, in crystals reproducing in the most complete manner the minute peculiarities, the surface markings and striations, of the natural mineral. For the production of corundum, a *flux* is employed, *i.e.* a substance which fuses at a moderate temperature and in which the alumina dissolves, to separate out on cooling in the crystalline form. The colour of the ruby—one of the varieties of corundum—is due, not to the substance of which it is mainly composed, but to a very small proportion of a colouring matter. By the addition of a small amount of a suitable material the red colour is obtained in the product of the laboratory, and by varying the colouring material sapphire and oriental emerald have been obtained. So far the size of the specimens has been small, one-third of a carat being about the maximum for rubies. The carat is equal to four grains. A cut ruby weighing a grain would be suitable for one of the smaller stones of a ruby ring. In the process of cutting, however, the weight is generally reduced by one half, so that the largest specimens yet produced are not adapted for employment as ornaments. They are, however, used in the jewelling of watches. The details of the method employed at the present time in their production are as follows. The chemically precipitated amorphous alumina is heated with barium fluoride, or a mixture of the fluorides of the alkaline earths, which acts as a flux, and a trace of bichromate of potash is added to impart the red colour. The addition of carbonate of potash, which renders the fused mass alkaline, furthers the formation of larger crystals. The heating is kept up for several days, at the end of which time a plentiful crop of crystals is obtained. Although the aggregate weight obtained in one operation amounts to some pounds, the individual crystals are, as has been said, small in size. It is frequently contended that the fact of reproduction is the only essential point, and that the size of the crystals produced is of little importance from the scientific point of view. It must, nevertheless, be allowed that the interest of this work will be much increased when products are obtained which will compare in size and beauty with those occurring in nature.

Of other gems, some—as the garnet and the spinelles—have been prepared; others, as the emerald, have hitherto proved less tractable. In the case of turquois, the artificially prepared substance has the chemical composition and the appearance of the natural stone; but inasmuch as the laboratory product behaves differently under certain conditions, as, for instance, when heated, it must be considered as an approximate reproduction only, if not looked upon as a mere imitation. The pearl is formed of aragonite, a mineral readily reproduced by evaporating a hot solution of carbonate of lime. The peculiar beauty of the pearl is, however, due to the structure resulting from its mode of growth. It would be rash to hazard an opinion as to whether this structure could be imparted by methods at the disposal of the chemist.

But the great problem in the artificial production of gems is the preparation of the diamond, and this problem is still unsolved. Popular prejudice has relegated the attempt to the same category as the endeavour of the alchemist to transmute the baser metals into gold. The aim of the alchemist was once a legitimate object of scientific research. In the light of modern ideas on the nature of chemical elements it is so no longer. The endeavour to obtain the element carbon in that transparent crystalline form in which it is found in nature, has certainly nothing in common with the work of the alchemist. Yet the light in which the attempt is viewed by the majority is still that so graphically described by Balzac in his ingenious novel, *La Recherche de l'Absolu*. Balthazar Claes devotes his life to the endeavour to reproduce the diamond, and "people would scarcely speak to him—a man in the nineteenth century seeking the philosopher's stone. They called him an alchemist, and said he might as well try to make gold. As he passed by in the street people pointed him out with expressions of pity or contempt." The want of success which has hitherto attended the efforts of the Balthazars of real life is perhaps scarcely to be wondered at. In the case of other minerals the successful reproduction has generally been achieved only after the minute study of the mode of natural occurrence, and this has afforded guidance as to the best means of imitating the natural process of formation. It is only of recent years that the diamond has been found in its original matrix, so that materials have been wanting on which to base experimental methods. The chemical nature of the body, a combustible substance, is so different from that of the ruby and most other gems, which are oxides or oxidized materials, that the methods to be employed for its production will probably involve the application of different principles. There is no reason, however, to regard the problem as insoluble. When sufficient guiding data have been obtained, skill will not be wanting to imitate in the laboratory the conditions under which Nature has worked in the formation of this most beautiful product of the mineral world.

THE HOUSE CRICKET.

By E. A. Butler.

Few domestic insects have succeeded in inspiring such widely different sentiments in the minds of their hosts as the House Cricket. To most people it is far better known by the evidence of the ears than of the eyes. Its shrill chirping, prognosticatory, according to popular belief, of cheerfulness and plenty, reveals the performer's presence when no trace of its person can be discerned; and like the similar sound made by its near relative, the grasshopper, it is one which there is great difficulty in localising or tracing to its origin. Distinct and intensely penetrating

though this "shrilling" is, yet most people find it a perplexing task to decide exactly from what quarter it proceeds. This constitutes an element of mysteriousness, and it is not surprising that the invisible minstrel should have been credited with occult influences. The feelings with which the sound has been regarded have accordingly varied with the disposition of the hearer, from superstitious reverence to downright dislike and extreme irritation. While to Milton, for example, "the cricket on the hearth" seemed no unsuitable accompaniment of thoughtful solitude, when the devotee of "divinest Melancholy" retires to

> Some still removed place . . .
> Where glowing embers through the room
> Teach light to counterfeit a gloom,

on Gilbert White, the naturalist of Selborne, the chirping of crickets had quite an opposite effect. Speaking of the Field Cricket, which is in most respects much like its cousin of the house, he remarks: "Sounds do not always give us pleasure according to their sweetness and melody; nor do harsh sounds always displease. We are more apt to be captivated or disgusted with the associations which they promote than with the notes themselves. Thus the shrilling of the field-cricket, though sharp and stridulous, yet marvellously delights some hearers, filling their minds with a train of summer ideas of everything that is rural, verdurous, and joyous."

If poet and naturalist do not agree here, still less are they in accord in other instances; if to the former the cricket is "Little inmate, full of mirth," "always harbinger of good," one whose song is "soft and sweet" (!), to the latter it is a "garrulous animal," keeping up a "constant din," "a still more annoying insect than the common cockroach, adding an incessant noise to its ravages." And while the simple and easy-going rustic life of olden times might tolerate and even enjoy this incessant clatter, the state of nervous tension at which so much of present-day life is lived will no doubt lead most people to agree with the naturalist here, rather than with the poet, and vote the cricket a household nuisance. The noise upon which such different views have been held is apparently a love-call, and is accordingly produced only by the males, the female crickets being, in fact, through the absence of the requisite machinery for chirping, absolutely dumb. To the cause of the noise we shall recur presently; meanwhile, we may consider the zoological position and the structure of the insect.

FIG. 1.—HOUSE CRICKET (*Gryllus domesticus*).

As a family the crickets enjoy a wide distribution, and in this country five species have been met with, though for some reason best known to themselves, only one has domesticated itself. The family is called *Gryllidæ*, and is closely allied to those of the grasshoppers and locusts, forming with them one of the great divisions of the order Orthoptera, viz. that of the "leapers." To another section of the same order, viz. the "runners," it will be remembered, the cockroach belongs. Our English domestic species (Fig. 1) is called *Gryllus domesticus*. At first sight a cricket strikes one as being not unlike a grasshopper in general form, the resemblance being caused chiefly by the great proportionate length and elevated position of the hind legs. In body, however, it is broader and flatter than a grasshopper, and in other respects is sufficiently distinct to be regarded as the type of a different family.

The mouth organs bear a close resemblance to those of the cockroach, as a comparison of the accompanying figures with those of KNOWLEDGE, vol. xii., p. 218, will testify. As one looks in the insect's face, the greater part of the mouth organs is concealed by a not very stout flap, hinged above and shaped like a cheese-cutter; this is the *labrum*, or upper lip. On lifting it, like the visor of a knight's helmet, there is disclosed a pair of stout, dark brown, horny, toothed jaws (*mandibles*, Fig. 2), which are used not merely to divide the food, but also as excavating implements, to hollow out retreats into which the insects can retire in the day-time or when alarmed. These mandibles again, when closed, completely cover the rest of the mouth organs; on their removal, the secondary jaws, or *maxillæ*, come into view (Fig. 3); these are very much like the cockroach's, the inner lobe (*lacinia*) being tipped with two sharp teeth, and received for protection's sake into a groove of the outer (*galea*), and they are furnished with a pair of five-jointed palpi. Beneath, or rather behind them, is the *labium*, showing again a similar structure to that of the prototype, and equally obviously composed of a pair of jaws which have coalesced, *i.e.* have become united into a single organ in their basal portion; this, too, carries a pair of palpi. The chief difference between the two insects is to be seen in the appendage to the labium in its centre, which is called the *lingula*, or "tongue." This is a most marvellous and exquisite structure, and deservedly a great favourite with microscopists. As shown in the figure, it is pressed out of place. On opening the mouth it will be seen on the floor, rising into a grooved, hollow, fleshy eminence. When flattened out it is found to be a kidney-shaped, leaf-like expansion, strengthened throughout by radiating fibres of chitinous material, which, when highly magnified, show a beautiful mosaic structure. Kitchen refuse of various kinds constitutes the food of these creatures, and a good deal of moisture as well seems to be necessary for their well-being. No doubt this curious tongue helps them in drinking. They have been accused of gnawing

FIG. 2.—MANDIBLE OF CRICKET.

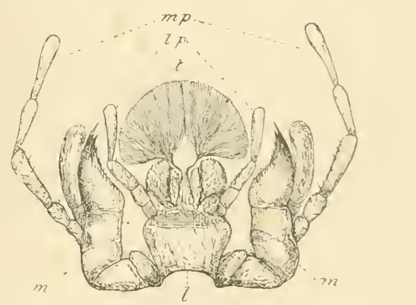


FIG. 3.—MOUTH ORGANS OF CRICKET. *m*, maxillæ; *mp*, maxillary palpi; *l*, labium; *lp*, labial palpi; *t*, tongue.

holes in stockings hung before the fire to dry, in order to satisfy their cravings for moisture. Hence, also, it is not an infrequent experience to find them drowned in pans or jugs of liquid.

The House Cricket is more or less of a pale brown colour throughout, and, unlike the cockroach, it is fully winged in both sexes, and, therefore, has no need of man's agency to supplement its powers of locomotion. It flies with an undulatory motion, making long rising curves in the air, and dropping at regular intervals. The wings are extremely beautiful objects; in fact, the house cricket contains so many exquisite and delicate structures, that anyone who has a few hours to spare and can devote them, with a good microscope, to the dissection of the insect, will find ample material for interesting study and observation. There are two pairs of wings, the upper pair being more or less horny and exceedingly different in males and females; and the under pair thin and membranous, and similar in both sexes. When closed, the right upper wing partly overlaps the left, and the under wings project in the form of long, tapering, rod-like pieces beyond the tips of the fore wings, extending about half as far again as these.

The fore wings are much broader than a casual glance would suggest, seeing that only about two-thirds of their width lies flat along the back, the other third being bent down at right angles to the rest, and lying close along the side. Those of the female are very regularly veined, there being two systems of nervures proceeding in opposite directions, one on each side of the stout ridge at which the wing is bent. But the wings of the male (Fig. 4) are extremely peculiar, and it is in them that the power of chirping resides. There is the same division into

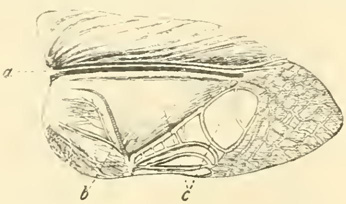


FIG. 4.—RIGHT FORE WING OF MALE CRICKET. *a*, line of bending; *b*, file; *c*, drum.

two areas as in the female, but the hinder section, *i.e.* the one that lies on the back, has its veins distributed very irregularly. A stoutish nervure runs straight across this near its base, and then beyond it a large clear triangular area is left almost devoid of nervures. At the apex of this, nearer still to the tip of the wing, is another similar, but smaller and four-sided, patch, with a single, pale, delicate nervure running across it, and the rest of the wing is covered pretty closely with a network of nervures. If, now, these wings be turned over and examined beneath, it will be found that the straight nervure aforesaid is crossed transversely by a large number of little hard ridges, giving it the appearance of an extremely fine file. These are much too small to be seen with the naked eye, but a moderate magnification coupled with careful focussing soon brings them into view. When the chirping is to be produced, the insect bends the fore part of the body slightly downwards, and then slightly raising the fore wings, rubs them rapidly across one another; during this motion, the file of one rubbing against the surface of the other produces a creaking vibration, which is greatly intensified by the clear, open plates above-mentioned, which are therefore called "drums." It will now be evident why the females are mute; they have neither "file" nor "drum," and hence are physically incapable of "singing."

It is clear from the above that the chirping is in no true sense of the word either a voice or a song, being quite unconnected with the respiratory organs; it is a purely external and mechanical sound, comparable, as a means of expressing sentiments, rather with the human device of clapping the hands, or flipping the fingers, than with the utterance of sounds with the mouth. Of course it is not to be expected that an insect should make any noise with its mouth other than that produced by eating, since the mouth does not, as is the case with us, communicate with the breathing organs. The entrances to these are in the cricket, as in all other insects, along the sides, and any sound that might be produced in them by the passage in and out of the air would be more strictly comparable with the voice of vertebrate animals; some insects, as for example, the common bluebottle-fly, are able to produce a noise in this way, and may therefore be truly said to possess a voice. But that is by no means the rule, and the sounds insects produce are in general the result of the friction of external parts upon one another.

The hind wings of the cricket are exceedingly delicate, and are each strengthened by about fifty nervures radiating fan-wise from the base. As about half these nervures are weaker than the rest, the weak ones being placed alternately with the strong ones, the whole wing can be folded up lengthwise like a fan, and this accounts for its pointed form as it protrudes from beneath the upper wing. It is this peculiar method of straight, longitudinal folding that has caused the name Orthoptera (*straight*-winged) to be given to the order.

Of course the power of chirping implies the power of hearing. It is only natural to suppose that the male crickets would long ago have abandoned the habit of serenading (if, indeed, they had ever perfected it) if their mates had not been able to recognise their attentions. It is rather curious, however, that this insect, notwithstanding its living in our houses, and the considerable curtailment of its field of quest for partners consequent thereupon, should have preserved almost as strongly as its outdoor relative this power of chirping; one cannot help feeling a suspicion that, if this vigorous minstrelsy be merely of an amatory nature, either the gentler sex in the cricket world have become extremely coy, or else there is a vast deal of wasted energy on the part of their swains. However that may be, as the power of recognition of this call seems as though it must be an important matter in cricket economy, we naturally look about for some special apparatus suitable for the detection of sounds, of a much more indubitable character than is generally met with in insects. And the search is soon rewarded. It is only necessary to examine the *tibia*, or shank, of the fore legs, just below its junction with the thigh, to find an organ to

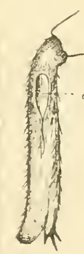


FIG. 5.—FORE TIBIA OF CRICKET, showing auditory organ (*a*).

which it is difficult to assign any other function. Here, on the flattened outer edge is a long, oval, transparent, membranous disc, stretched over a corresponding aperture in the walls of the leg (Fig. 5), and exactly opposite it, on the other side of the leg, there is a similar, but round and much smaller disc; between these two, in the centre of the hollow shaft of the leg, is a bladder-like expansion of the main breathing-tube of the leg. Numerous curiously shaped nerve-endings, having the peculiar form of those

of special sense, are distributed at this spot, and the action of the complex apparatus seems to be such that the membranous disc, vibrating in response to the chirping of some distant individual, communicates its motion to the air within the breathing-tube, which in its turn affects the neighbouring nerves, thus enabling the insect to perceive the sound.

Projecting from the hinder part of the female's body is a long ovipositor, consisting of a double boring implement, used in depositing the eggs in suitable situations. Large numbers of eggs are laid, and the course of development is similar to that of the cockroach or bed-bug, the eggs yielding small, active, six-legged creatures, something like their parents in form; after a series of moults, these attain by progressive changes, but without any pause in their activity or suspension of their functions, the adult size and form, acquiring wings only at the last moult. The metamorphosis is thus incomplete.

Two long, unjointed, tapering appendages, pointing backwards, project from near the extremity of the abdomen in both sexes. They are furnished abundantly with very fine hairs, and are probably sense organs, possibly giving notice of impending danger from behind.

Crickets are pugnacious insects amongst their own kind; notwithstanding similarity of habits, however, they are often found inhabiting the same houses as cockroaches. But it seems probable that the steadily advancing armies of the latter insect will, in the course of time, either exterminate them, or compel them to take to an out-door life. This latter they are not averse to doing in the summer time even now. But from the way in which they hug the kitchen fire, it seems as if artificial warmth is essential for them in the winter.

CLUSTERING STARS AND STAR-STREAMS.

By J. E. Gore, F.R.A.S.

THE general tendency of the stars to gather into groups, more or less marked, is perhaps indicated by their ancient division into constellation figures. In the Northern Hemisphere we have the well-known groups of the "Plough" (Ursa Major), "Cassiopeia's Chair," the "Sickle" in Leo, Corona Borealis or the Northern Crown, and Orion; and in the southern hemisphere the Southern Cross, Scorpion, Corvus, &c. The "Dolphin's Rhomb," the head of Hydra, and the group near the binary star 70 Ophiuchi also form examples of this clustering tendency.

That in some of these groups, at least, the connection is real and not merely apparent is shown by the community of "proper motions" discovered by the late Mr. Proctor in the five stars of the "Plough," β, γ, δ, ϵ, and ζ*—a connection afterwards verified by Dr. Huggins's spectroscopic observation of their motion in the line of sight. We have a similar case in "Cassiopeia's Chair," where several of the stars in this well-known group seem to be moving in the same general direction through space.

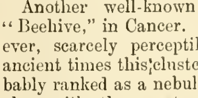
Among the lucid stars, the most remarkable examples of this clustering tendency are found in the smaller groups, such as the Hyades and Pleiades. In the latter cluster—perhaps the most remarkable group of stars in the heavens—six stars are visible to ordinary eye-sight, but some persons gifted with keener vision can see a larger number.* There is a tradition that seven stars were originally visible to average eyes, but that one disappeared at the capture of Troy. With reference to this supposed disappearance of the "lost Pleiad," Professor Pickering has recently discovered that the spectrum of Pleione (which forms a wide pair with Atlas) bears a striking resemblance to that of P. (34) Cygni, the so-called "temporary star of 1600." The similarity of the spectra shown by these two stars suggests that Pleione may—like the star in Cygnus—be subject to occasional accessions of light, which may, perhaps, account for its possible visibility to the naked eye in ancient times. Examined with a telescope the Pleiades show an enormously increased number of stars—even with an opera-glass a considerable number may be seen—and in a photograph of the group, taken at the Paris Observatory with an exposure of three hours, no less than 2,326 stars can readily be counted in a space of about 3 square degrees. In this remarkable picture, smaller aggregations of stars are visible; for instance, Alcyone, the brightest of the whole group, forms one of a small cluster of some ten stars, and Maia and Merope have several faint stars near them. A common proper motion in many of the brighter stars of the Pleiades shows that here also we have a family of stars travelling through space together.

The Hyades also form a remarkable naked-eye group, with the brilliant red star, Aldebaran, as their leader, but the component stars are not so closely crowded as in the Pleiades group. I am not aware whether the Hyades have yet been photographed.

Another well-known cluster is the Præsepe, or the "Beehive," in Cancer. The stars composing it are, however, scarcely perceptible to the unaided eye, and in ancient times this cluster, from its nebulous aspect, was probably ranked as a nebula, and perhaps placed in the same class with the great nebula in Andromeda, which was also known to the earlier astronomers.

Coma Berenices is another example of a scattered cluster. Here the stars are brighter, and may be well seen with an opera-glass.

Among clusters a little beyond the limits of naked-eye vision, there are many interesting examples of star clustering which may be seen with a binocular or good opera-glass. One of the most remarkable of these surrounds the star 5 Vulpeculæ. I give two drawings of this curious little asterism, one (Fig. 1) as seen by myself with a 2-inch telescope, and the other (Fig. 2) as drawn by Mr. Espin, with a reflecting telescope of 17¼ inches aperture. The tendency of the brighter stars to run in lines will be noticed, and the curious grouping of fainter stars towards the left of the larger diagram is also remarkable. This group should be photographed. It is surrounded by Milky Way light, according to both Boeddicker and Heis.



About 2¾ degrees preceding the bright star Pollux I see a small cluster of stars, of about the 7th and 8th magnitudes, which, with a binocular field-glass, very much resembles the Pleiades as seen with the naked eye. The stars 10, 11 and 12 Geminorum (north preceding μ

* Dr. Auwer's subsequent determinations have, however, shown that in three of these stars, β, γ, and δ, the "proper motion" is small and doubtful. We have, however, a quintuple system in ϵ, ζ, Alcor, and the telescopic and spectroscopic companions of ζ.

* Miss Airy is said to have seen 12, and Möstlin (according to Kepler) no less than 14.

Geminorum) also lie in a small cluster of stars, which may also be well seen with a binocular.

The well-known double cluster χ Persei may be seen with an opera-glass, but a telescope is necessary to see the component stars, and the larger the instrument the greater the number visible in these wonderful objects, which, like many somewhat similar clusters, lie in the Milky Way. This twin cluster has been well photographed at the Paris Observatory, and also by Mr. Roberts. On the Paris photograph—at least, in the paper print in my possession—the clusters are clearly resolved into stars

Fig 2
Group near ι Vulpeculæ
17½ inch reflector (Espin)
Stars to 10½ magnitude

with no trace of outstanding nebulosity, suggesting that the component stars are probably at nearly the same distance from the earth.

The cluster 39 Messier, between π' and 71 Cygni, may be well seen with a binocular, in which it somewhat resembles the Pleiades as seen with the naked eye.

Another fine open cluster will be found a little north, following β Ophiuchi. Between β and γ Ophiuchi is a remarkably blank spot. On August 15, 1890, I failed to glimpse the faintest star with binocular in a clear, moonless sky, a striking contrast to the rich region north of β. A similar blank space will be found just north of the stars π and ϕ Aquilæ (north of Altair). On September 3, 1886, I could only see glimpses of very faint stars with the binocular in a sky clear and moonless, a remarkable vacuity so close to a region of bright stars, and a good example of an interesting stellar feature, namely, rich and poor regions in close proximity. I may here mention that a region of considerable extent, remarkably barren of bright stars, will be noticed with the naked eye in the northern hemisphere. This comparatively poor region, which contains no star brighter than the 4th magnitude, is bounded by Cepheus, Cassiopeia, Perseus, Auriga, Gemini, Ursa Major, Draco, and Ursa Minor, and forms a conspicuous feature in the north-eastern portion of the sky in the early winter evenings. It will be noticed that the bounding constellations all contain conspicuous stars.

Examined with a telescope, the heavens afford numerous instances of stellar aggregation. The Milky Way forms, of course, the most remarkable example, on a great scale, but among comparatively isolated groups there are numerous interesting objects. Of these, the cluster known as 35 Messier—a little north of the variable star η Geminorum—is visible in an opera-glass, but a telescope is required to see the component stars. A very beautiful photograph of this cluster has been taken at the Paris Observatory. A well-marked clustering tendency is visible among the brighter stars of the group, two, three, four, and sometimes five stars being grouped together in subordinate clusterings.

In the southern hemisphere a splendid cluster of small stars surrounds the star κ Crucis. Sir John Herschel charted 110 stars to the 7th magnitude and fainter. Some of the component stars are coloured with red, greenish, and bluish tints, which, he says, "give it the aspect of a superb piece of fancy jewellery." It lies near the northern edge of the well-known "Coal-sack," and Dr. Gould says of it: "The exquisitely beautiful cluster κ *Crucis* contains a large number of stars of various tints and hues, contrasting wonderfully with each other, when viewed with a telescope of large aperture." A drawing by Mr. Russell of this cluster, made in 1872, shows some well-marked star-streams.

Just north of ζ Scorpii is a bright cluster which I found visible to the naked eye in the Punjab sky as a hazy star of about $4\frac{1}{2}$ magnitude. With a 3-inch refractor the components were well seen.

The so-called "globular clusters" form excellent examples of the clustering tendency, but here the component stars lie so close together that their physical connection cannot be doubted.

Among groups of stars not usually classed as clusters there are many examples of this aggregating tendency visible on the stellar photographs taken at the Paris Observatory. Photographs of portions of the Milky Way in Cassiopeia, Gemini, and Lyra show the small stars to be in many places not scattered uniformly, but with a marked tendency to cluster into subordinate groups adjoining comparatively starless spaces. This is especially noticeable on a photograph of a portion of the constellation Gemini (R.A. 6h. 10m., N. 20° 20′), a little south of η Geminorum. On these photographs many cases occur in which three, four, or more stars are grouped together, often in a straight line, or nearly so, and to all appearance comparatively isolated from their surrounding neighbours. On a photograph of a rich Milky Way region in Cygnus (R.A. 19h. 45m., N. 35° 30′) taken by Mr. Roberts at Liverpool, with an exposure of 60 minutes, on which no less than 16,206 stars may be counted (in an area of about 4 degrees), similar features are noticeable.

In his observations of the Milky Way in the southern hemisphere Sir John Herschel says: "Here (R.A. 17h. 50m., S. 33°–36°) the Milky Way is composed of separate, or slightly, or strongly connected clouds of semi-nebulous light; and as the telescope moves, the appearance is that of clouds passing in a *scud*, as the sailors call it." "I could fill a catalogue with the clusters of the 6th class which are here. The Milky Way is like sand, not strewn evenly as with a sieve, but as if flung down by handfuls (and both hands at once), leaving dark intervals, and all consisting of stars 14 . . . 16 . . . 20m. down to nebulosity, in a most astonishing manner."

No. 2,908. "Cluster 7th class. The second of two stars 9m. which may be considered the leading stars of the very large and fine cluster of the Nubecula Major, which fills many fields, is of all degrees of condensation and much broken up into groups and patches. . . . The field full of grouping stars."

The tendency of the stars to run in streams is pointed out by Proctor in his *Universe and the Coming Transits* (first two chapters). Among the lucid stars the most remarkable instances of this stream-forming arrangement are found in Pisces, Scorpio, "the river Eridanus," the streams in Aquarius, and the festoon of stars formed by η, γ, α, δ, and μ Persei. The stream forming the constellation Eridanus was noticed by the ancients (as the name "river" implies), but in this case the stars are so far apart that the connection is probably more apparent than real. Perhaps the same may be said of the streams forming Scorpio and Pisces, but still they are sufficiently well-defined to attract the eye of even a casual observer. Other examples of the kind may be seen in Corona Borealis,

or the Northern Crown; in Corona Australis in the southern hemisphere; and also among fainter stars visible to the naked eye, or with an opera-glass.

But it is among the still fainter stars—those visible only with a telescope or revealed by photography—that we find the most striking examples of this stream-forming tendency. In these cases the small stars composing the streams are comparatively close together—at least, apparently so—and for this reason the evidence in favour of a real physical connection is proportionately stronger. Webb says*: "A little *n. p.* μ Sagittarii xviih. 57m., S. 18° 50′ is a spot referred to by Secchi as exemplifying in a high degree the marvellous structure which the great achromatic at Rome shows in the Galaxy. The remarks of this accomplished astronomer on the successive layers of stars are very curious: first he finds large stars and lucid clusters; then a layer of smaller stars, certainly below 12 mag.; then a nebulous stratum with occasional openings. But what he says startled him, and all to whom he showed it, was the regular disposition of the larger stars in figures 'si géométriques qu'il est impossible de les croire accidentelles. La plus grande partie sont comme des arc de spirale; on peut compter jusqu'à 10 ou 12 étoiles de la 9me. à la 10me. grandeur. . . . Se suivant sur une même courbe comme les grains de chapelet; quelquefois elles forment des rayons qui semblent diverger d'un centre commun, et ce qui est bien singulier, on voit d'ordinaire que, soit au centre des rayons, soit au commencement de la branche de la courbe, on trouve une étoile plus grande et rouge. Il est impossible de croire que telle distribution soit accidentelle.' "

I have already noticed that on the Paris stellar photographs many cases may be seen of three or more stars placed in a straight line, or nearly so. Sometimes a comparatively bright star seems to draw a train of fainter stars after it, like the tail of a comet, and occasionally a stream of stars of nearly equal brightness may be traced for some distance from their source. In the photograph of the cluster 38 Messier, this stream-formation is well marked among the brighter stars. Webb describes it as "a noble cluster arranged as an oblique cross."†

Observing with a 3-inch telescope in India, in July 1874, I noticed a beautiful cluster of stars about 4° north of λ and ν Scorpii, resembling, in shape, a bird's foot, with remarkable streams of stars. This cluster is visible to the naked eye as a star of 5 or $5\frac{1}{2}$ magnitude.

Sir William Herschel, speaking of the compressed cluster H. vi. 25 in Perseus, says, "the larger stars are arranged in lines like interwoven letters"; and, Webb says, "it is beautifully bordered by a brighter foreshortened pentagon."

From the close proximity of the component stars—of some at least of these clusters—the reality of a physical connection between them seems beyond dispute, and from analogy we may conclude, I think, that "streams" and "sprays" of stars in other portions of the heavens are, in some cases at least, due to a real and not merely an apparent connection.

From a telescopic examination of the Milky Way, Professor Holden finds numerous star-streams, and also arrangements forming "small definite ellipses" of stars, often all of the same size. . . . In certain parts of the sky, the arrangement is so intricate that no single pattern can be discovered. In most regions a little attention will show that there are several patterns, one for each of the fainter magnitudes of stars" (*Monthly Notices*, R.A.S., Dec. 1889).

In a paper in the *Monthly Notices*, R.A.S., for April 1890, Mr. Backhouse calls attention to the "straight lines and parallel arrangements of pairs, lines, and bands of stars, and also of irresolvable wisps" observed by him in a portion of the Milky Way included between the stars 15, 13, 8 Monocerotis, α Orionis, ζ Tauri, and 5, μ, ξ Geminorum, and "besides the parallelisms" he notes "a most wonderful case of *radiation of stars and wisps* in a fan-shaped group, 68 Orionis being approximately the centre." He finds a preponderance of the groupings "at an average deviation of 15° from the direction of Gould's Galactic Equator, viz. at a position angle of 345° with that great circle, and more nearly parallel with a Galactic Equator derived from Proctor's chart of the *Durchmusterung* stars, and he adds: "One conclusion derived from the investigation is that the stars and wisps in parallel lines are probably in the same region of space; and therefore that the majority of the stars—at least of those down to the 9th or 10th magnitude—in extensive tracts of the area examined are really near one another."

An examination of Dr. Boeddicker's beautiful drawing of the Milky Way seems to show that the Galaxy itself is —at least, chiefly—composed of "star-streams" and "star-sprays" and clustering groups of small stars, and does not represent a "cloven" flat disc, as was originally supposed.

Mr. Proctor pointed out that "the nebular system also shows the most marked tendency to stream-formation." In the great nebular region in Virgo and Coma Berenices, he finds that "the stars are not arranged uniformly over either region, but to some degree clusteringly with interspersed spaces relatively vacant. Now no nebula appear in the more vacant spaces, nor do nebula appear chiefly where the stars are more clustered. It is on the borders of star-clusterings, and in the breaks of star-streams, that the nebulæ show themselves, precisely as though they had taken the place of stars where star-matter began to fail." This fact, considered in connection with Laplace's Nebular Hypothesis, is very remarkable and suggestive. The nebulæ seen in the streams may possibly represent stars in their initial stage.

* *Celestial Objects*, Fourth Edition, p. 385, foot-note.
† *Ibid.*, p. 241.

WHAT IS A VOLCANO?

By the Rev. H. N. Hutchinson, B.A., F.G.S.

IN old days volcanoes were regarded with superstitious awe, and any investigation of their action would have been considered rash and impious in the highest degree. A certain "burning mountain" in the Lipari Isles, called Volcano, was considered to be the forge, or workshop, of Vulcan, the god of Fire. And so it comes about that all "burning mountains" take their name from this island in the Mediterranean.

In the present paper it will only be possible to consider two aspects of the subject of volcanoes, which may, perhaps be more suitably presented in the form of questions, viz. (1) *What is a volcano?* (8) *What are the chief phenomena of volcanic action?*

In the first place, a volcanic mountain consists of alternating sheets of ash and lava, mantling over each other in an irregular way, and all sloping (or "dipping," as geologists say) away from the centre. In the centre is a pit, or chimney, widening out towards the top so as to resemble a funnel or a cup. Hence the name "crater," which means a cup. In the centre of the cone there is frequently a little minor cone. As our readers will pro-

bably be aware, many of the lunar volcanic craters also possess these little minor cones, which are well seen in some of the larger photographs of the moon's surface. A number of cracks, or fissures, radiating from the central orifice, intersect the volcano. These get filled with lava welling up from below, and from what are called "dykes," which may be regarded as so many sheets of igneous rock —basalt or felsite, as the case may be—that have, while in a molten condition, forced their way in among the layers of ash and lava. The word "ash" is used by geologists in a special sense; and volcanic ash is not, as might be supposed, a deposit of cinders, but mostly of dust of various degrees of fineness; and sometimes it is very fine indeed. It is synonymous with the word "tuff." Pieces of pumice-stone may be embedded in a volcanic tuff, but they only form a small part. How these volcanic tuffs are formed we shall explain presently.

Dykes strengthen the mountain and tend to hold it together when violently shaken during an eruption. But notwithstanding, it sometimes happens that the whole structure is blown to pieces by some unusually violent outburst.

The shape and steepness of a volcano vary with the nature of the materials ejected. The finer the volcanic tuff the steeper and more conical is the mountain. The formation of a volcano may not be inaptly illustrated by the little cone of sand formed in an hour-glass as the sand-grains fall. The latter settle down to a certain slope, or angle, at which they can remain in their place. This is known as the "angle of repose." When the materials are coarse the angle is less. When they are fine the angle is greater. The district of Auvergne in France contains a number of very interesting extinct volcanoes, some of which were formed principally of a thick and viscous lava which slowly welled up from below, and in so doing formed round and dome-shaped little hills such as the "Puy de Dome." Vesuvius, Teneriffe, Jorullo in Mexico, and Cotopaxi in the Andes, are examples of steep volcanoes built up principally of volcanic tuff. Others, more irregular in shape, such as Kilauea in the Sandwich Islands, are largely built up by successive lava-flows. Little minor cones are frequently developed on the flanks of a volcano, which during eruptions give rise to small outbursts on their own account. They are easily accounted for by the dykes which we mentioned just now; for when the molten rock forces its way through the fissures, it sometimes finds an outlet at the surface, and, being full of steam, as soda-water is full of gas, it gives rise to an eruption. The central orifice, with its molten lava, is, as it were, a great dyke which has reached the surface and so succeeded in producing an eruption. The opening of a soda-water bottle not infrequently illustrates a volcanic eruption; for when the pent-up carbonic acid cannot escape fast enough it forces out some of the water, even when the bottle is held upright.

Lastly, every volcano is built up on a platform of stratified rocks, or strata, laid down in the usual way under water, and at some period subsequent to their formation molten matter came up from below, and found its way through them to the old land-surface which they formed. Earthquake shocks preceding the first eruption probably cracked up the strata, and so facilitated the uprise of the lava with its imprisoned steam.

The main point which we wish to emphasize is that volcanoes are *never* formed by upheaval. They must not be regarded as blisters due to the swelling or upheaval of strata, but, as we have endeavoured to explain, they are gradually built up from below, and may be compared to rubbish heaps, which grow by gradual accumulation. But in the case of volcanoes, the rubbish comes from below. It is not necessary to suppose that the subterranean reservoirs from which the molten rock is supplied, exist at any very great depth below the original land-surface on which the volcano grows up. Indeed, the evidence we at present possess, from the denuded areas of volcanic action, goes to show that this is not the case.

The old "upheaval theory" of the formation of volcanoes, once advocated by certain geologists, instead of being based upon actual evidence, or reasoning from facts, as modern scientific theories are, was a mere guess. Moreover, if the explanation we have given should not be sufficiently convincing, there is the proof furnished by the case of a small volcano near Vesuvius, whose formation was actually witnessed. It is called Monte Nuovo, or the New Mountain. This mountain is a little tuff-cone, 430 feet high, on the bank of Lake Avernus, with a crater more than a mile and a half wide at the base. It was mostly formed in a single night, in the year 1538 A.D. We have two accounts of the eruption to which it owes its existence, and each writer says distinctly that the mountain was formed by the falling of stones and ashes.

One witness says: "Stones and ashes were thrown up with a noise like the discharge of great artillery, in quantities which seemed as if they would cover the whole earth; and in four days their fall had formed a mountain in the valley between Monte Barbara and Lake Averno of not less than three miles in circumference, and almost as high as Monte Barbaro itself—a thing incredible to those who have not seen it, that in so short a time so considerable a mountain should have been formed." Another says: "Some of the stones were larger than an ox. The mud [ashes mixed with water] was at first very liquid, then less so, and in such quantities that, with the help of the afore-mentioned stones, a mountain was raised, 1,000 paces in height." These accounts are important as showing how, in a much longer time, a big volcano may be built up. They are examples, or little epitomes, of slow and vast processes which Nature vouchsafes to us, and which enable us to comprehend her actions when they are on a larger scale.

We must now consider briefly the second question. The following are the chief phenomena of a great eruption:—Its advent is heralded by earthquakes, affecting the mountain and the whole country round; loud subterranean explosions are heard, resembling the fire of distant artillery. The vibrations are chiefly transmitted through the ground; the mountain seems convulsed by internal throes due, no doubt, to the efforts of imprisoned vapours and liquid rock to find an opening. These idications are accompanied by the drying up of wells and disappearance of springs, since the water finds its way down new cracks resulting from the explosions. When at last an opening has been effected, the eruption begins, generally with one tremendous burst, shaking the whole mountain down to its foundations. Frequent explosions follow with great rapidity and increasing violence, generally from the crater. These are indicated by the globular masses of steam which are to be seen rising up in a tall column like that which issues from the funnel of a locomotive. The elastic gases in their violent ascent hurl up into the air a great deal of solid rock from the sides of the crater, after first blowing out the stones which previously stopped up the orifice.

Blocks of stone falling down meet with others coming up, and so a tremendous pounding action takes place, the result of which is that great quantities of volcanic dust are produced, generally of extreme fineness. Winds and ocean currents transport these light materials for long

distances. Recent researches show that fine volcanic dust is universally distributed over the sea. The darkness so frequently mentioned in accounts of eruptions is caused entirely by clouds of volcanic dust obscuring the daylight. The red clay deposits in the deepest and most remote parts of the ocean are now considered to be chiefly composed of oxidized volcanic dust.

Portions of liquid, or semi-liquid, lava are caught up by the steam and hurled into the air. These assume a more or less spherical form, and are known as "bombs." At a distance they give the appearance of flames. And here we may remark that the flaring, coloured pictures of Etna or Vesuvius in eruption, which frequently may be seen, are by no means correct. The huge flames shooting up into the air are imaginary—another case of a popular fallacy—but probably suggested by the glare and bright reflection from incandescent lava down in the crater.

But there is another way in which a good deal of fine volcanic dust, or ash, is produced; and it is this—the lava is so full of steam intimately mixed up with it that the steam, in its violent escape, often blows the lava into mere dust. This might be illustrated by the cloud of spray seen for a moment after a soap-bubble has burst; and we can well imagine that something like this takes place in a boiling and seething mass of lava in a crater during eruption. The steam, we ought to mention, is not dissolved in the lava, but absorbed by it, and is said to be "occluded" (hidden away).

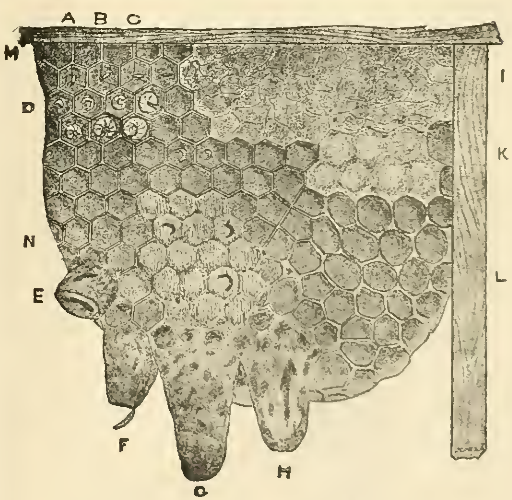
When lava-flows take place the lava does not always come from the crater, but often issues from the side of the volcano. This marks the crisis of the eruption, and now a gentle decline sets in. The volcanic forces have done their worst, and the lava-column begins to sink. Explosions decrease in violence, less ash is ejected, and finally cinders choke up the orifice; and so the volcano, as it were, chokes up itself.

So great is the force of the pent-up steam trying to escape that it frequently blows a large portion of the top of the volcano bodily away, leaving only a truncated cone; and, in some cases, a whole mountain has been thus blown to pieces. Finally, torrents of rain follow or accompany the upthrust of so much steam into the air. Vast quantities of volcanic ash are caught up by the rain, and in this way large quantities of mud are washed down the sides of the mountain. Sometimes the mud-floes are formed on a large scale, and, descending with great rapidity, bury up a whole town. It was in this way that the ancient cities of Herculaneum and Pompeii were buried up by the great Vesuvian eruption of A.D. 79. The Italians give the name *lava d' acqua*, or water-lava, to flows of this kind, and they are greatly dreaded on account of their very rapid flow. An ordinary lava-stream creeps slowly along, so that people have time to get out of the way; but in the case of mud-flows there is often no time for escape.

Into the question of the cause of volcanic phenomena we cannot enter now; but we shall have more to say in a second paper.

Notices of Books.

The Honey-Bee: Its Natural History, Anatomy, and Physiology. By T. W. Cowan, F.L.S., &c. (Houlston & Sons.) This little manual, which, though consisting of upwards of 200 pp., is scarcely larger than pocket-size, forms the natural supplement to the author's numerous works on Bees and Bee-culture. The subject is handled in an exhaustive and thoroughly scientific manner, and the book, which is written in a commendably concise style, and contains upwards of seventy figures, teems with reliable information. The labour of compilation must have been great, and the author deserves the thanks, not only of apiculturists, but of all who are interested in the anatomy and physiology of insects in general, for having put into such a compact and inexpensive form so much of the detailed results of recent scientific research. Authorities are constantly cited throughout, and the references to the copious bibliography appended supply the reader with all that is necessary to guide him in pursuing the subject further. Taking a look into a hive at the height of its activity, we are introduced to the queen "moving slowly over the combs, surrounded by a number of workers, which are constantly touching her with their antennæ, and offering her food. She stops at an empty cell, examines it by putting her head inside, then, hanging on to the edges of the comb, inserts her abdomen, and deposits at the base of the cell, to which it is attached by a glutinous secretion, a little bluish-white oblong egg." The position of the egg in the cell is altered day by day, till, sloping gradually from the upright, it eventually lies in a horizontal direction, as shown at A, B, C, in the

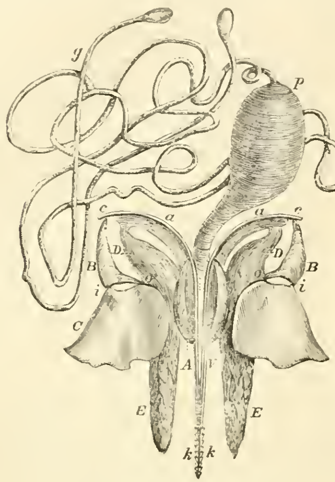


A Brood-comb and Royal Cells.

accompanying figure of a brood-comb. Here also are shown the growing grub, the remarkable crater-like openings of the royal cells, drone cells at K, and at N cells containing workers, some of which are just nibbling their way out through the cappings of the cells. Mr. Cowan considers that bees generally confine their honey- and pollen-collecting expeditions to within a radius of about two miles from their hives, except when food is scarce, when they will fly as far as four or five miles. By his own observations he has proved that the rate of flight may be at least as much as twelve miles an hour, *i.e.* for unweighted bees, the heavily-laden ones returning from a foraging expedition, of course travelling more slowly.

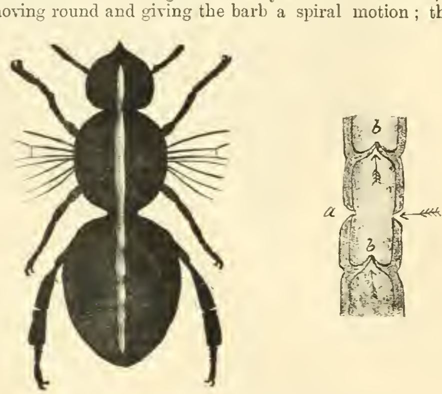
Great pains have been taken to give a clear exposition of the mechanism and method of action of the sting.

which is much more complex than might have been imagined. The accompanying figure shows the long tubular poison-gland which passes its secretion, consisting chiefly of formic acid, into the large reservoir at the base of the sting; the two lancets the latter contains may move either simultaneously or alternately, and at each stroke the



Bee's Sting and Poison-Gland.

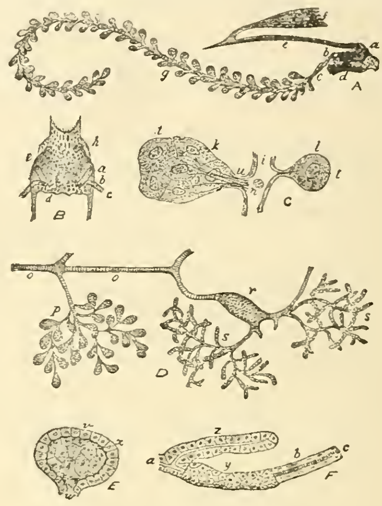
poison is forced into the wound with considerable energy through canals in the lancets themselves, and out at the openings between the barbs. Though the queen rarely stings a human being, yet the writer's experience shows that she can do so if necessary. He states also that she can withdraw her sting more easily than the workers, by moving round and giving the barb a spiral motion; this,



Dorsal Vessel or "Heart" of Bee.

he maintains, the worker could do also, but that she is in such a hurry to get off that she does not give herself time, but tears herself away, leaving the sting and its appendages behind her. Mr. Cowan has adopted the striking and effective device of showing different systems of organs separately *in situ* on the dark background of the body; one of these illustrations, exhibiting the dorsal vessel, or "heart" of the bee, is here appended; the small explanatory diagram added shows how the blood enters by the side openings of this valvular tube, and is propelled towards the head.

No subject is more debateable than the functions of antennæ, and hence much interest attaches to the chapter dealing with the researches that have been made into the structure and function of the tactile hairs, and of the curious sensory pits in these organs in the bee, which have by some authors been considered to be smell hollows, and by others an auditory apparatus. The accompanying



Salivary Glands.

figures of the salivary glands of the bee will give an idea of the neatness with which the histological illustrations are executed. Mr. Cowan has made many measurements of the cells of the comb, with the view of testing the accuracy of commonly-received notions as to their extreme regularity, and he finds that frequently considerable deviations from the normal size and shape of the cells occur. Following Müllenhoff, he maintains that "the complexity and apparent accuracy of the structure is not in the least owing to the development of a mathematical instinct in bees, or artistic dexterity, but simply to physical laws dependent on their method of work," the cells behaving "mutually like soap-bubbles, which when isolated are round, but, if touching each other, where united the film forms a perfectly flat wall." One or two misprints occur in the technical terms, as *e.g.* "vasa *dif*-ferentia" for "*de*-ferentia," and "vesiculæ seminal-*is*" for "seminal-*es*."

Celestial Motions; a Handy Book of Astronomy. By W. T. Lynn, B.A., F.R.A.S. Seventh Edition. (London: E. Stanford.) We are pleased to welcome a new edition of Mr. Lynn's very handy little manual, the sixth edition of which was reviewed in Knowledge for June 1889. In the present one the information appears to have again been carefully brought up to date, reference being made to Schaparelli's results with respect to the rotation of Mercury and Venus, and to the identity of the comet discovered by Brooks in July 1889 with what is generally known as Lexell's comet of 1770. No notice, however, is

taken of the "spectroscopic binaries" discovered at Harvard and Potsdam. There are very few misprints in the work, but we must demur to the statement on page 9 that the resulting mean distance of the moon from a parallax of 57′ 2″ is 237,300 miles. As a matter of fact the mean distance of the moon is about 238,840 miles, the average distance is *not* the mean of the maximum and minimum values of the distance, and a parallax of 57′ 2″ would answer to a distance of about 238,900 miles.—H. S.

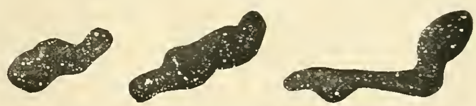
THE PLEIADES CLUSTER, AND ITS PROBABLE CONNECTION WITH THE MILKY WAY.

By A. C. RANYARD.

THE Pleiades lie a little to the south of the Milky Way, in a line with the Hyades—the three great stars in the Belt of Orion, and Sirius, the brightest star in the heavens. This striking chain of jewels lies nearly parallel with the Milky Way, just outside its southern border. It forms part of a great belt or stream of bright stars first noticed by Sir John Herschel,* and subsequently more closely studied by Dr. B. A. Gould,† which appears to girdle the heavens very nearly in a great circle that intersects the Milky Way at an angle of about 20°, crossing it near the margin of the Southern Cross, and in the northern hemisphere again crossing the Milky Way in Cassiopeia. This stream of bright stars, like the stream of milky light it crosses, is more striking in the southern hemisphere than in the northern, and one can hardly doubt its intimate connection with the stream of smaller stars with which it appears to be associated.

Of the twelve brightest stars in the heavens which rank as of the first magnitude or brighter than the first magnitude, seven lie in this brilliant girdle of stars, and three are intimately associated with it, being situated only just on the opposite border of the Milky Way. Taking the stars in their order of brightness according to Professor Pickering's photometric catalogue, they stand thus:—1. *Sirius*, ranked as of the −1·4 magnitude; 2. *Arcturus*, 0·0 magnitude, that is, one magnitude brighter than the first magnitude; 3. *Capella* and *Vega*, both ranked as of the 0·2 magnitude; 5. *β Orionis*, 0·3 magnitude; 6. *Canopus*, 0·4 magnitude; 7. *Procyon*, 0·5 magnitude; 8. *α Orionis*, 0·9 magnitude; 9. *α Centauri*, a double star, one component of which is of the 1·0 magnitude and the other 3½ magnitude; 10. *Aldebaran*, *α Aquilæ*, and *α Eridani*, all three ranked as of the 1·0 magnitude. Of these stars *Aldebaran*, *α* and *β Orionis*, *Sirius*, *Canopus*, *α Centauri*, and *Vega* lie in the zone of brilliant stars alluded to above, while *Capella*, *Procyon*, and *α Aquilæ* lie, at no great distance, on the opposite border of the Milky Way. According to Professor Gould, *Capella* and *α Aquilæ* lie on a well-marked branch of this great star-stream, which bifurcates during half its course round the heavens similarly to the Milky Way.

At first sight, no doubt, it seems altogether improbable that such large stars could be associated with very small and apparently distant stars; but the evidence afforded by the Pleiades group, as well as by other clusters, shows that one star differs from another star in brightness, not merely ten or a hundred times, but certainly as much as a hundred thousand times, while the small streams and closed curves of stars in the Milky Way contain stars which differ several magnitudes in brightness, and yet fall so accurately into lines and curves that we can hardly doubt their physical association with one another. The accompanying three small groups of stars have been cut from an automatically-prepared block made from Mr.



Barnard's photograph of the *Sagittarius* region. Such closed curves of stars generally surround dark spaces, or lie along the edges of dark channels. The great dark arch shown in the photograph of the *Sagittarius* region, published in the July number of KNOWLEDGE last year, seems to be a succession of such dark regions, each surrounded by curves of stars. I only refer to them here as showing that various magnitudes of stars seem to be associated together in the brighter parts of the Milky Way, and that we must not assume that there is not as great a range of actual magnitudes in and about the Milky Way as we shall see, there seems to be very little doubt, are associated together in the Pleiades cluster.

The Rev. John Michell, in a paper published in the *Phil. Trans.* for 1767, seems to have been the first to apply the doctrine of probability to the question whether the *Pleiades* group corresponds to an actual cluster of stars in space, all of which are relatively near together, or whether it probably corresponds to a series of stars at various distances from us, but all lying near to the same line of sight. Considering the views then in vogue as to the uniform distribution of stars with respect to the sun's position in space, the paper is a very masterly one. He concludes that there must be some physical connection between the numerous double and triple stars which had already been discovered by Sir William Herschel, but which were not then known to be moving under the influence of mutual gravity, and that such groups of stars as the clusters in the sword-handle of Perseus and the Pleiades must be actual clusters. Summing up, he says: "We may conclude with the highest probability (the odds against the contrary opinion being millions to one) that the stars are really collected in clusters in some places, where they form a kind of system, whilst in others there are either few or none of them."

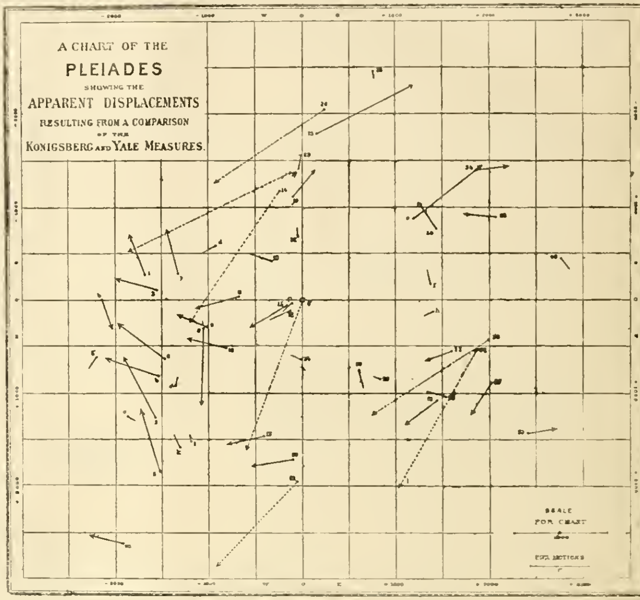
The Pleiades group forms a very irregularly-shaped

* Sir John Herschel says of it, in his *Results of Astronomical Observations made at the Cape of Good Hope*, p. 385:—"The medial line of the Milky Way may be considered as crossed by that of the zone of large stars which is marked out by the brilliant constellation of *Orion*, the bright stars of Canis Major, and almost all the more conspicuous stars of *Argo*, the Cross, the Centaur, *Lupus* and Scorpio. A great circle passing through *ε Orionis* and *α Crucis* will mark out the axis of the zone in question, whose inclination to the galactic circle is therefore about 20°, and whose appearance would lead us to suspect that our nearest neighbours in the sidereal system (if really such) form part of a subordinate sheet or stratum deviating to that extent from parallelism to the general mass which, seen projected on the heavens, forms the Milky Way."

† Prof. Gould says, in the *Uranometria Argentina*, p. 355:—"A stream of especially conspicuous stars, which, beginning with *Orion*, includes the brightest in *Canis Major*, *Columba*, *Puppis*, *Carina*, *Crux*, *Centaurus*, *Lupus*, and the head of *Scorpius*. In the northern hemisphere its course is less distinctly marked, and it is especially indistinct in *Ophiuchus* and *Hercules*; but its general direction is indicated by the brightest stars in *Taurus*, *Perseus*, *Cassiopeia*, *Cepheus*, *Cygnus*, and *Lyra*. This belt seems to bifurcate in a manner somewhat analogous to the Milky Way. A well-marked branch diverges from the main stream, not far from *α Centauri*, traversing the Galaxy, which it spangles with the bright stars of *Sagittarius* and of the tail of *Scorpius*, and passing through *Aquila* and *Delphinus*, reunites with the principal belt in the north-preceding portion of *Andromeda*. This bifurcation is likewise much less manifest in the northern hemisphere than in the southern, the bright stars being more scattered, and the course of the divided stream less distinctly traceable."

cluster, without any marked condensation towards a centre, and it would not be opposed to probabilities or unreasonable to suppose that we might be looking at two clusters superposed or projected on one another in the line of sight; if this was the case, the smaller stars might belong to one cluster, and the larger to the other and nearer cluster, and we should then not be warranted in assuming that differences in apparent magnitude amongst the stars of the group must correspond to differences in actual brightness or size of the stars. If there were two such clusters entirely unconnected with one another, we might expect to find a difference in the proper motion or drift of the two families of stars, or a difference in their spectra, which might enable us to sort out and distinguish the stars belonging to the two groups. The measurement of the relative positions of the stars in the Pleiades group has occupied the attention of several distinguished astronomers. This was one of the first problems which Bessel attacked with the Königsberg Heliometer. It occupied his attention during about twelve years, until the work was finally completed in 1841. Dr. Wolf of the Paris Observatory, Prof. Simon Newcomb, Prof. Pritchard, and ultimately Dr. Elkin of Yale, have all devoted much time and care to determining the positions of the stars of this group. The accompanying chart shows the proper motions of the chief stars of the group as determined by Dr. Elkin, by comparing his own measures made with a six-inch heliometer with those made by Bessel nearly half a century previously. The chart is copied from Dr. Elkin's memoir, which forms the first volume of the *Transactions of the Astronomical Observatory of Yale University*.* It will be seen that there are seven stars with large proper motions towards the north-west, all of them, with the exception of *Alcyone*, being small stars. They are shown with arrows having dotted or broken lines on the chart, corresponding to the amount and direction of the proper motions. With the exception of *Alcyone*, the other six lucid stars of the group have comparatively small proper motions.

In Dr. Elkin's map the larger stars are distinguished by letters. Both the letters and numbers are those used by Bessel. The map corresponds to the inverted image of the stars as they are seen in the telescope, and it must therefore be turned round through 180° to make it correspond with Mr. Isaac Roberts's photograph, or with the plate given in the January number of Knowledge for 1889. It is remarkable that the general direction of drift of these seven stars is very similar to the reversed absolute motion of *Alcyone* in 45 years as given by Prof. Newcomb, viz. 2″·61. There seems to be little doubt that these seven stars are only optically associated with the cluster, and have no physical connection with it. Of the remaining 33 stars whose positions were compared, two,



viz. Nos. 8 and 25, have a considerable and similar proper motion towards the south-east, which would seem to render it probable that they are associated. The star No. 8 has, according to Prof. Pickering (see *Memoirs of the American Academy*, vol. xi., p. 214), a spectrum which shows the K line broad and differs materially from the first type of spectra exhibited by most of the other members of the group. The spectrum of No. 25 is uncertain, as it is overlapped by the spectrum of another star; 27 and 39 also have peculiar spectra. Setting these aside as probably only optically connected with the group, the remaining stars have only comparatively small proper motions, and seem to have similar spectra of the first type. There appears to be a tendency to community of drift in adjacent parts of the group, such as might well be exhibited by the stars of an irregular cluster moving under mutual attractions.

Assuming all the other stars, with the exception of the eleven referred to above, to belong to one cluster, they would all be at about the same distance from the earth, and their actual brightness may be taken to correspond to their apparent brightness. Prof. Pickering has measured the light of 298 of these stars, varying from a little below the third magnitude down to the 15·3 magnitude of the photometric scale.* There are many fainter stars in the group, though the instrument used by Prof. Pickering did not enable him to measure their brightness. Thus the Brothers Henry photographed within the same area,

* It should be mentioned that Professor Pritchard has given a chart of the proper motions of the stars of the Pleiades group in the *Memoirs* of the Royal Astronomical Society, vol. xlviii., p. 272, which does not at all agree with that given by Dr. Elkin. But the practical agreement of Dr. Wolf's measures with those of Dr. Elkin, as well as other considerations, seems to show that, although a very small probable error is claimed by Professor Pritchard, Dr. Elkin's map is probably the most reliable. I do not place much reliance on the smaller proper motions deduced by Dr. Elkin, that do not amount to half a second in a century, for such an error would about correspond to the quarter of a second of probable error of the Königsberg observations as deduced by the accurate Bessel.

* See vol. xviii. of the *Harvard Annals*, p. 202.

THE GREAT NEBULA IN THE PLEIADES.

From a Photograph taken by Mr. Isaac Roberts, 8th December, 1889, with a 20-inch silver-on-glass reflecting telescope, and an exposure of four hours.

which corresponds to the catalogue and map of M. Wolf, 1,421 stars in 1885, and they have since brought the number up to 2,326 by exposures of four hours made in November and December 1887. A difference of only twelve and a half magnitudes of the photometric scale implies that the brighter stars give 100,000 times as much light as the fainter. Mere differences of brightness in the stars composing two streams amounting to 12 or 14 magnitudes must not, therefore, be taken as reliable evidence of a difference of distance, if other facts point to an association or probable connection between the two streams.

No one who examines the accompanying plate will feel inclined to doubt that the nebulous matter shown must be associated with the large stars of the group, and that the streaks of nebulous light are associated with the small stars through which they pass. It has long been recognized that the large and irregular nebulæ, as well as the great clusters, are associated with the Milky Way, and are grouped in its neighbourhood; and one can hardly doubt that the nebulous matter associated with so many stars of the Orion group is intimately associated with the main stream of the Milky Way.

Dr. Boeddicker, in his large drawing of the Milky Way made at Parsonstown, gives a stream of nebulous light extending from the main body of the Milky Way, and including the brighter stars of Orion, a view to which probability is lent by the form and position of the numerous large nebulæ in this constellation catalogued by Dr. Dreyer and Prof. Pickering. One of these large nebulæ, streaming southward for about 60′ from the bright star ζ *Orionis*, has recently been well photographed by Dr. Max Wolf of Heidleburg, though it had previously not been overlooked by Dreyer, and had been photographed by the Brothers Henry* as well as by Prof. Pickering. A strange nebulous line of light in this Orion region, reminding one of the nebulous lines joining stars in the Pleiades group, has been photographed at Harvard. It extends from D.M. $-8°$ 1119 in R.A. 5h. 19m. 0., Dec.$-8°$ 40′ to D.M.$-8°$ 1132 in R.A. 5h. 21m. 6s., Dec.$-8°$ 50′, and passes through about sixteen faint stars.† Other lines of stars are also strikingly evident in this constellation. I have already, in the March number of Knowledge, referred to the remarkable symmetry of the curvature of the branching structures in the great Orion Nebula, with respect to an axis perpendicular to the general plane of the Milky Way. These facts leave very little doubt in my mind as to the existence of an intimate connection between the nebulous matter associated with the bright stars of the Orion group and the great stream of the Milky Way, and I am consequently led to conclude that the girdle of bright stars in which the Orion group and the Pleiades lay, is not widely separated from the stream of smaller stars forming the Galaxy, and that in any case the one cannot be so much nearer to us than the other, that the difference of apparent magnitude of the stars in the two streams may be accounted for by the difference of the distance of the streams.

It does not necessarily follow from the large parallax which has been found for α *Centauri* that it cannot belong to the stream of large stars referred to, none of which have been found to exhibit any similarly large annual shift; for the modern parallaxes, which are chiefly or entirely relied upon, are all relative and not absolute parallaxes; that is, they are determined from measures made with respect to adjacent small stars. If the adjacent stars belong to a stream which is in near proximity to the large stars, as compared with their distance from the earth, we should not expect to find any relative shift, while here and there a large star might be seen projected near to much more distant stars. On the other hand, probably, many will prefer to assume that α *Centauri* only chances to lie in a zone of brilliant stars, the rest of which are much more distant, and consequently much larger or brighter, than the star which we now recognize as our nearest neighbour.

The plate illustrating this paper has been made from a photograph kindly given to me for the purpose by Mr. Isaac Roberts. It will be noticed that the direction of the upper streak of nebulous light is continued by a line of stars which extends nearly all across the plate, and that there is a somewhat similar line of stars extending from *Pleione* (the bright star just to the north of *Atlas**) nearly across the plate just to the north of *Alcyone* and *Electra*. The eight rays crossing the brighter stars, and making them appear like the conventional symbols for stars on a star map, are due to a diffraction effect caused by the arms supporting Mr. Isaac Roberts's camera in the focus of his mirror.

* See *Rapport Annuel sur l'Etat de la Observatoire de Paris pour l'Année* 1887.

† See *Annals of Harvard College Observatory*, vol. xviii., p. 115.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

ON THE COMPARISON OF THE PHOTOGRAPHS OF THE MILKY WAY IN α=17h. 56m. δ= $-28°$ IN "KNOWLEDGE" FOR JULY 1890, AND MARCH 1891.

To the Editor of Knowledge.

Dear Sir,—I have read with much interest Mr. Ranyard's article in Knowledge for March 1891, about the photographs of the Milky Way in 17h. 56m., $-28°$, made by me in 1889, and by Mr. Russell in 1890.

I have no hesitation in attributing the difference between these pictures (taken with instruments so similar) entirely to the development of the negative. As I have taken occasion to remark elsewhere (Pub. A.S.P. II. 10), the utmost care must be exercised in the development of the Milky Way pictures to bring out the cloud forms clearly and strongly.

It will be seen that Mr. Russell's photograph was given one hour and twenty minutes longer exposure than mine, and with a zenith distance on the meridian of only 6°, while the zenith distance here was 65°. The plates used for the Lick Observatory pictures were Seed, sensitometer No. 26. They are among the best that are made. I have examined Mr. Russell's photograph and can find no evidence of change in the cloud forms of the Milky Way as shown on his picture and mine. It is an extremely uncertain thing to compare two photographs like these, where one shows only feebly the cloud forms and the other shows them strongly and conspicuously. An exact comparison, however, may be made by densely overprinting the picture made here, so that the cloud forms will become as feebly shown as are those in the Sydney picture. Such a comparison I have made. The two photographs are identical in every respect, except that there are apparently several large stars near the middle of Mr. Russell's picture which are not shown on mine, and which are undoubtedly defects in his plate.

I forward to you the photograph which I have used for comparison with Mr. Russell's. You will see the two are

* For the names of the Pleiades stars, see the diagram in Knowledge for January 1889.

identical. Yet this picture (which you would not recognize on comparison) was made from the same plate as that published in the July 1890 issue of Knowledge.

Mr. Ranyard says, at the bottom of page 50 (Knowledge for March 1891): "In Mr. Barnard's picture there are two clusters of stars near to the edge of the field at the bottom of the plate. Only one of these clusters, viz. that to the right hand, or western side, is shown in Mr. Russell's plates." It is the *left-hand*, or *following*, cluster

which is shown on Mr. Russell's picture. The right-hand one is too far to the right to be shown on his plate, though a small bunching of stars immediately following it is visible close to the right-hand edge of the picture, 2·6 inches from the bottom.

I would remark here, as a caution, that it is extremely unsafe to judge of the actual relative brightness of different surfaces, such as the Milky Way presents, from photographs which have been treated differently in point of time and development. A partially brought out configuration will have in many cases, a decidedly different aspect from that of a carefully and thoroughly developed one.

Yours respectfully,

E. E. Barnard.

Mount Hamilton, March 16, 1891.

[As mentioned in the March number of Knowledge, it is quite easy to account, by assumed differences in the method of development or differences in the sensitiveness of the plates used, for the fact that so little nebulous brightness is shown on Mr. Russell's plates as compared with Mr. Barnard's; but the remarkable fact which cannot be so accounted for is that the relative brightness of the nebulous areas on the two sets of photographs does not correspond. For example: the two brightest areas on Mr. Barnard's photographs are (1) towards the lower part of the great tree-like structure on the preceding side, and (2) a large area on the south following side of the tree-like structure. But Mr. Russell's photographs do not exhibit any trace of nebulosity in these regions, while there is distinct nebulosity shown in the fainter head of the tree-like structure. Mr. Barnard's densely-printed photograph of his own negative—which I have had reproduced as a printing-block by a photographic method—is very interesting; but I do not concur with him that the large stars near the middle of Mr. Russell's picture "are undoubtedly defects" in Mr. Russell's plate. They may be due to defects in the collotype copies which I forwarded to Mr. Barnard.—A. C. Ranyard.]

PERPETUAL CALENDARS.

To the Editor of Knowledge.

Dear Sir,—As the subject of finding the day of the week for any given date appears to interest a large section of the readers of your valuable magazine, I enclose for your acceptance (agreeably to the promise given in your February issue) a few rules bearing upon the subject of "Old Style" dates, all of which have been verified from that valuable work, Sir Harris Nicolas's *Chronology of History*. The rules appear to me to be as simple and correct as those previously given, and moreover possess the additional advantage of being serviceable "anywhere and everywhere" without the extraneous aid of discs or any other office aid.

Yours faithfully,

Robt. W. D. Cristie.

Rule I.—The last day of July of any "Old Style" date may be got thus:—

Take the year, add a quarter, divide by 7.

Example 1.—The Armenian Era commenced July 9th, A.D. 552. On what day of the week was it?

We have 552
add 138

7) 690

98+4 = Wednesday = 31st July.

Thus Tuesday was the 9th July 552.

Rule II.—Take the year, add a quarter, take away the the No. of the month, divide by 7. The remainder indicates the last day of month.

Example 1.—On what day of the week was March 31st, 1000?

We have 1000
add $\frac{1}{4}$ 250

1250
subtract 3 = No. of month of March.

7) 1247

178+1 = Sunday.

Thus March 31st, 1000 (Easter Day), fell on Sunday.

Example 2.—King Richard I. died on Tuesday, the 6th April 1199. Prove this.

1199
299

1498
3

7) 1495

213+4 = Wednesday = 31st March.

Thus 6th April was on Tuesday.

Example 3.—Richard II. resigned his crown on Monday, 29th September 1399. Test this.

```
     1399
      349
     ----
     1748
        9
     ----
  7) 1739
     ----
      248 + 3 = Tuesday = 30th September.
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Thus the 29th September was Monday.

Many useful minor rules might be added, but intelligent readers can form these for themselves; and all interested in the subject of "*dates*" should provide themselves with the invaluable work mentioned above.

STATIONARY OR LONG-ENDURING RADIANTS OF METEORS.

To the Editor of Knowledge.

Dear Sir,—Although the readers of Knowledge are already aware of the existence of Stationary or Long-Enduring Radiants of Meteors, they are not, perhaps, fully acquainted with the evidence in their favour, or of the difficulties which arise in attempting to explain them.

The evidence in favour of such long-enduring radiants will, I think, appear conclusive to anyone who arranges the observations comprised in a long catalogue, like that of Mr. Denning in the Monthly Notices of the Royal Astronomical Society for May 1890, in order of Right Ascension instead of date. I have done this with a considerable number of catalogues, which generally confirm each other. The force of this kind of evidence may be illustrated by analysing the radiants in Mr. Denning's Catalogue situated between R.A. 260° and R.A. 270° (the sign + indicating Northern, and the sign − Southern Declination). Here is a complete list of them:—

260° + 2°	Apr. 19.	263° + 69°	Aug. 21, 23.
260° + 33°	Apr. 18.	264° + 62°	Aug. 14, 23.
260° + 45°	Jan. 14,17.	264° + 64°	Apr. 30, May 8.
260° + 62°	Apr. 19, 26.	264° + 64°	May 28, 30.
260° + 63°	Sept. 5, 15.	265° + 77°	Apr. 26, May 3.
260° + 68°	July 24.	266° + 33°	Apr. 18.
260° + 69°	July 27, 29.	266° + 47°	Aug. 22.
261° + 4°	Feb. 15, 20.	266° + 63°	July 13.
261° + 5°	June 3, 13.	267° + 70°	Sept. 4, 7.
261° + 63°	Jan. 19, 25.	267° + 21°	Apr. 19.
262° + 64°	May 11, 14.	267° + 49°	July 15, 20.
262° + 64°	June 9, 13.	268° − 24°	June 10, 20.
262° + 64°	Oct. 5, 12.	268° + 33°	Apr. 19.
263° + 36°	Feb. 20, 21.	269° + 31°	Apr. 19.
263° + 48°	Mar. 14.	269° + 33°	Apr. 20.
263° + 61°	July 29, Aug. 2.	269° + 37°	Apr. 16, 19.
263° + 62°	Mar. 28.	269° + 49°	July 20, 31.
263° + 62°	Apr. 20, 22.		

Six of these are determinations of the radiant of the Lyrids (April 18–20) in different years, but the occurrence of a radiant near the same point in February suggests a doubt as to whether even this radiant is of very brief duration. One half of the entire number appear to belong to a radiant situated between + 60° and + 70°, which continues active almost throughout the year. Five others belong to a radiant situated between + 45° and + 50°, and three to a radiant between 0° and 5°. The pair at + 20° and + 21° are also probably connected; and the isolated radiants are thus reduced to two, one at +77° and the other at − 24°. The failure to trace the latter radiant at other times of the year probably arises from its great Southern Declination; and we thus seem led to the conclusion, not merely that stationary radiants exist, but that they are the rule—a conclusion which, I believe, further analysis of published observations will only tend to confirm.

About a quarter of a century ago the close correspondence between certain meteor-showers and the orbits of certain comets was ascertained, and since then the cometary character of meteor-showers has been generally assumed. Difficulties arise at once when we endeavour to combine this cometary character of the showers with the fact of stationary radiation. We can only fall in with a cometary shower when the earth is at a moderate distance from the comet's orbit, and if this orbit has a high inclination to the ecliptic, the corresponding shower can only be encountered when the earth is near the node. High inclinations, however, predominate among the comets (if we except the comparatively small class of comets of short period), and in the case of the comet which has been connected with the August Perseid shower the inclination exceeds 66°. But that the activity of this radiant is not limited to the month of August appears certain. Thus, Mr. Denning, on reducing the Italian observations of 1872, found that it had continued active (though with diminished intensity) during the last five months of the year. Reverting to our table, the radiant situated at about 263 + 63° is not far from the pole of the ecliptic, and therefore, if cometary, would require a high inclination in the corresponding cometary orbit; but the shower apparently lasts throughout the year. Again, if a cometary meteor-train was sufficiently diffuse to produce a shower of considerable duration, the radiant point would not be constant but would shift from night to night; whereas the constancy of the radiant (within the limits of error) is the fact with which we are dealing. Some observers, indeed, believe that they have observed a shifting in certain radiants; but the instances are few and doubtful, and the amount of observed shifting does not appear to agree well with the cometary theory.

The Copernican principle, that we perceive relative not absolute motion, is of course applicable to the apparent motions of meteors, and as the fixed stars are so distant as to be practically in the same direction at all periods of the year, the apparent motion of a meteor among the fixed stars will vary with the direction of the earth's motion at the time. Hence when the direction of the earth's motion varies (the velocity being always pretty nearly the same), the apparent position of the radiant must vary, assuming that the meteors still come to us from the same direction. But we have seen that in a great number of cases there is no perceptible change in the position of the radiant at different periods of the year, and hence arises a difficulty altogether independent of the cometary theory.

The late Mr. Proctor's solution of this difficulty is known to the readers of Knowledge. The amount of the displacement of the apparent radiant depends on the relative velocities of the earth and the meteors, and if the velocities of the meteors is very great compared with that of the earth, the displacement will be very small—and the observations are consistent with a very small displacement. But observation tends to show that meteors coming from stationary radiants do not possess this very high velocity. Few of the showers appear to be as fast as the Leonids, whose velocity has been computed from the corresponding comet at 44 miles per second. Some of them are noted by Mr. Denning as "slow" or "very slow"; and, what is perhaps the most conclusive evidence

that their velocity is comparable to that of the earth, they always (so far as I have traced) appear to move faster or slower according as the earth is receding from or approaching the radiant. The explanation of the phenomenon must therefore be sought elsewhere, but there is as yet no satisfactory theory on the subject.

It seems clear, however, either that the meteors belonging to the same long-enduring shower (though, no doubt, physically connected with each other in some way) are not originally moving in parallel lines, or else that their original parallelism is by some means destroyed before they are sufficiently heated in the atmosphere to become luminous. And this departure from parallelism (whether original or acquired) must follow a peculiar law, which almost compensates the displacement of the apparent path caused by the earth's motion. Totally unconnected meteors could not be collected into groups by terrestrial aberration in the manner that we find them collected when we analyse any calalogue; just as a number of stones thrown at random into a current will not be collected into a heap by the action of the water. What we experience is plainly the result not of chance but of law; but of a law which remains to be discovered.

Yours faithfully,

W. H. S. Monck.

[The degree of certainty with which meteor radiants have been determined has, I think, been generally much over-rated. Observations made during rich showers prove that the meteor-tracks drawn backwards amongst the stars do not all meet in a point, but they appear to radiate from an area of as much as five or six degrees in diameter; the reason for this divergence no doubt being that meteors are irregularly shaped bodies, which, on plunging into the air, are deflected from their original course in a manner similar to that in which an irregularly shaped body, such as a shell, is turned out of its original course when thrown into water. Occasionally meteors have such projections or irregularities that their course through the air appears sensibly curved. The degree of certainty with which a radiant can be determined depends on the magnitude of the radiant area, as well as on the number of meteors observed. If there are several radiants supposed to be active on any night, an observer has to exercise his judgment in determining which among the many intersections with other meteor-paths he will select for the radiant. No doubt the length of the meteor-path gives some indication as to whether the visible part of the track is near or far from the radiant; but the length of the path is also affected by the magnitude of the meteor and its velocity, and there must frequently be very considerable uncertainty in selecting from amongst many intersections. In such cases the bias of the observer will no doubt produce its effect. We cannot judge as to the probability of the actual existence of any radiant without knowing the number of intersecting meteor-tracks from which it has been determined. Radiants determined from only two or three intersections of meteor-paths not all observed on the same night ought, I think, to have very little weight attached to them.

I cannot accept Mr. Proctor's suggestion that such stationary radiants correspond to a rain of sporadic meteors coming from certain directions out of space; for if the earth's motion in its orbit causes no shift of the radiant, we should have to assume such a velocity for these sporadic meteors that they would at once be detected by the different character of the streak left. According to Mr. Denning, some of the meteors from these stationary radiants are quite slow-moving.

No one has at present, as far as I am aware, plotted down all the observed radiants on a globe; marking those which fall near together, but do not occur in the same month; and taken a photograph of the globe to exhibit the grouping. Such a graphic method would no doubt enable the eye to judge better of the grouping, and the relation of the groups to the places of bright stars, than any inspection of tables. I have plotted down the radiants referred to in Mr. Monck's letter. They fall into three or four well-marked groups; but the dates of the adjacent radiants are not uniformly distributed round the year, as one would expect on Mr. Monck's hypothesis.—A. C. Ranyard.]

THE FACE OF THE SKY FOR MAY.

By Herbert Sadler, F.R.A.S.

Both spots and faculæ continue to appear on the solar surface. The following are the times of minima of some of the Algol type variables (*cf.* Knowledge, March and April, 1891), which may be conveniently observed at Greenwich.

U Cephei.—May 4th, 0h. 31m. A.M.; May 9th, 0h. 11m. A.M.; May 13th, 11h. 51m. P.M.; May 18th, 11h. 31m. P.M.; May 23rd, 11h. 11m. P.M.; May 28th, 10h. 50m. P.M.

S Cancri.—May 7th, 11h. 51m. P.M.; May 26th, 11h. 7m. P.M.

δ Libræ.—May 7th, 6h. 44m. P.M.

U Coronæ.—May 14th, 0h. 27m. A.M.; May 20th, 10h. 9m. P.M.; May 27th, 7h. 51m. P.M.

Owing to his proximity to the sun, Mercury is not well situated for observation in May. On the 1st he sets at 8h. 39m. P.M., or 1h. 18m. after the sun, with a northern declination of 20° 27′, and an apparent diameter of $10\frac{3}{4}''$. He is then inferior to a 5th-magnitude star in brightness, about $\frac{7}{100}$ of the disc being illuminated. He is in inferior conjunction with the sun at 3h. A.M. on the 10th, at a distance of about $51\frac{3}{4}$ millions of miles from the earth, being then in transit over the solar disc; a phenomenon which may be well observed in the western part of the United States and of South America. At Greenwich the sun rises at 4h. 18m. A.M. on that day, and external contact at egress takes place at 4h. 50m. 25s. A.M., at an angle of 168° from the north pole towards the west (counting for direct image). At egress the sun will be only about 4° above the horizon at Greenwich. After this Mercury becomes a morning star, but is too near the sun to be observed, as on the 31st he only rises 36m. before that luminary.

Venus is a morning star, but is too near the sun to be very conveniently observed. On the 1st she rises at 3h. 37m. A.M., or 57m. before the sun, with a northern declination of 0° 49′, and an apparent diameter of $13\frac{1}{2}''$, eight-tenths of her disc being then illuminated. On the 31st she rises at 2h. 46m. A.M., or 1h. 5m. before the sun, with a northern declination of 13° 45′, and an apparent diameter of $11\frac{1}{2}''$. She has then only a little more than a quarter of the brightness she possessed at the beginning of January, about $\frac{87}{100}$ of her disc being illuminated. During the month she passes through Pisces into Aries, but without approaching any conspicuous star very closely.

Mars and Jupiter may be considered to be, for the purposes of the amateur, invisible. Saturn is an evening star, rising on the 1st at 1h. 20m. P.M., with a northern declination of 9° 37′, and an apparent equatorial diameter

of 18½″ (the major axis of the ring system being 42½″, and the minor 4·0″). On the 31st he rises at 11h. 22m. A.M., with a northern declination of 9° 28′, and an apparent equatorial diameter of 17½″ (the major axis of the ring system being 40¼″, and the minor 3¾″). On the evening of the 5th Titan is about 20″ south of the planet; and on that of the 12th about 22″ north. On the 14th Iapetus is about 35″ south of Saturn. On the evening of the 21st Titan is about 20″ south of Saturn, and may just possibly be eclipsed by the shadow of the planet. On the evening of the 28th Titan is *nf* of the planet. Uranus is an evening star, rising on the 1st at 6h. 0m. P.M., with a southern declination of 10° 33′, and an apparent diameter of 3·8″. On the 31st he rises at 3h. 55m. P.M., with a southern declination of 10° 11′. He describes a short retrograde path to the N.N.E. of 86 Virginis during the month. Neptune is in conjunction with the sun on the 28th. There are no well-marked showers of shooting stars in May.

The moon enters her last quarter at 1h. 51m. P.M. on the 1st; is new at 6h. 16m. A.M. on the 8th; enters her first quarter at 7h. 4m. P.M. on the 15th; is full at 6h. 26m. P.M. on the 23rd; and enters her last quarter at 6h. 55m. P.M. on the 30th. She is in perigee at 9h. A.M. on the 5th (distance from the earth 227,015 miles), in apogee at 5h. A.M. on the 17th (distance from the earth 251,380 miles), and in perigee again at 9h. A.M. on the 31st (distance from the earth 229,565 miles). The greatest western libration is at 4h. 10m. A.M. on the 11th, and the greatest eastern at 0h. 44m. A.M. on the 24th. There will be a total eclipse of the moon on the 23rd, which may be well observed in India. At Greenwich only a small portion of the eclipse is visible; the moon rising at 7h. 56m. P.M., and totality ending three-quarters of an hour previously. The last contact with the shadow takes place at 8h. 17m. P.M., at an angle of 90° from the northernmost portion of the moon's limit towards the west (counting for direct image). The last contact with the penumbra takes place at 9h. 21½m. P.M.

Whist Column.

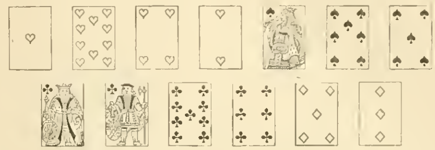
By W. MONTAGU GATTIE, B.A.Oxon.

THE MANAGEMENT OF TRUMPS.

At the commencement of a hand, the question whether or not trumps should be led, although often difficult, can nevertheless be decided, in the large majority of instances, on certain definite lines familiar to players of experience. Differences of opinion exist, no doubt, as to the proper course in particular cases, and there is wide scope for diversity of style. There is, perhaps, no point of the game into which the "personal equation" enters more conspicuously, and a man's position in a scale of character ascending from the extreme of caution to the extreme of temerity might not inaccurately be gauged by his management of trumps. But, given a particular player, he will nearly always be able to decide, as soon as he takes up his cards, whether he will lead trumps or not.

The case is different when the game has progressed some stages, and when, at a critical moment, the question of a trump lead has to be determined. General rules have ceased to be applicable, and there is no longer so much margin for individuality. The only safe guides are judgment and observation, and these are the distinguishing marks of the brilliant player. The following hand furnishes an interesting example of the importance attaching to a right decision under such circumstances:—

HAND No. 20.



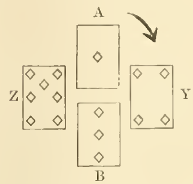
B's Hand.

Score—AB, love; YZ, 3.

Z turns up the ace of clubs.

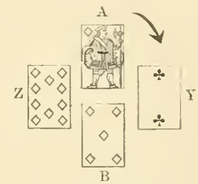
NOTE.—A and B are partners against Y and Z. A has the first lead; Z is the dealer. The card of the leader to each trick is indicated by an arrow.

TRICK 1.



Tricks—AB, 1; YZ, 0.

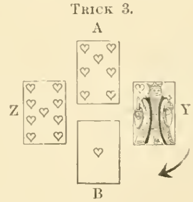
TRICK 2.



Tricks—AB, 1; YZ, 1.

NOTE.—*Trick* 2.—Z has the king of diamonds; A has all the other diamonds; and Y, having ruffed a doubtful trick, is weak in trumps.

TRICK 3.

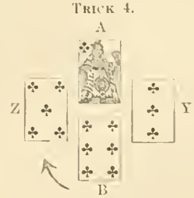


Tricks—AB, 2; YZ, 1.

NOTE.—From the fall of the cards, Y has led from at least six hearts; he holds the queen, and not the knave. A can only have the knave, eight; and Z can only have the knave, unless he has commenced a call for trumps.

FIRST LINE OF PLAY.

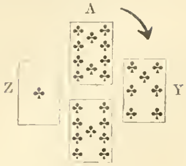
TRICK 4.



Tricks—AB, 3; YZ, 1.

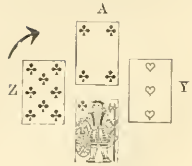
NOTE.—B desires neither to open spades, nor to lead hearts up to Y's strength. Holding four trumps to two honours, he leads through Z's ace up to Y's declared weakness.

Trick 5.



Tricks—AB, 3; YZ, 2.

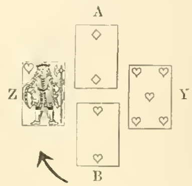
Trick 6.



Tricks—AB, 4; YZ, 2.

Note.—Z's lead was to be expected, for his partner clearly has no more trumps, and the four is marked in A's hand.

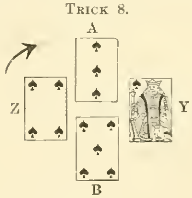
Trick 7.



Tricks—AB, 4: YZ, 3.

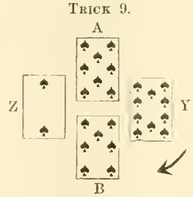
Note.—B's lead will either clear his ten of hearts, or throw the lead into Z's hand, who then must open spades. A spade is of no avail, unless both A's spades are winning cards (the diamonds being not yet established); and, in this fortunate event, only one trick is lost by the heart lead.

Trick 8.



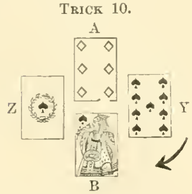
Tricks—AB, 4; YZ, 4.

Trick 9.



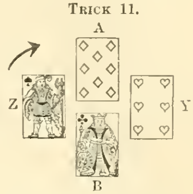
Tricks—AB, 4: YZ, 5.

Trick 10.



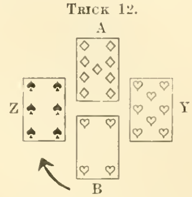
Tricks—AB, 4; YZ, 6.

Trick 11.



Tricks—AB, 5; YZ, 6.

Trick 12.



Tricks—AB, 5; YZ, 7.

Y makes the queen of hearts, and

YZ Score Two by Cards and Game.

Remarks.—If B leads a small spade at trick 7, Y, on winning with the nine, should return the king at once, and follow with the ten; Z wins with the knave, draws B's trump with the ace, and then makes the knave of hearts, the king of diamonds, and the last spade.

Trick 8.—It would, of course, be bad play at this stage of the game for Z to lead out the ace of spades.

Trick 9.—Z passes his partner's ten; for, if B holds queen, nine, he can only have one heart, and, after trumping Y's hearts, must lead a spade.

Second Line of Play.

Trick 4.—B plays the two of hearts, Z the knave of hearts, A the four of clubs, Y the three of hearts. *Tricks*, AB, 3; YZ, 1.

Note.—B argues that, if A has knave, eight, of hearts, he can only have three trumps, and these on the hypothesis that he has no spades, so that there is small prospect of his bringing in his diamonds, which are not yet established. If A has no hearts, AB have a cross ruff; if he has the eight, and Z the knave, B's ten will remain guarded; and, if Z is void and discards, A's knave will draw the queen, and B will have command of the suit.

Trick 5.—A plays the eight of diamonds, Y the seven of clubs, B the nine of clubs, Z the king of diamonds. *Tricks*—AB, 4; YZ, 1.

Trick 6.—B plays the four of hearts, Z the two of spades, A the ten of clubs, Y the five of hearts. *Tricks*—AB, 5; YZ, 1.

Trick 7.—A plays the queen of diamonds, Y the three of clubs, B the king of clubs, Z the ace of clubs. *Tricks*—AB, 5; YZ, 2.

Note.—A asks B for his best trump.

Trick 8.—Z plays the five of clubs, A the queen of clubs, Y the six of hearts, B the six of clubs. *Tricks*—AB, 6; YZ, 2.

Trick 9.—A plays the nine of diamonds, Y the nine of spades, B the ten of hearts, Z the eight of clubs. *Tricks*—AB, 6; YZ, 3.

Trick 10.—Z plays the four of spades, A the three of spades, Y the king of spades, B the five of spades. *Tricks*—AB, 6; YZ, 4.

Trick 11.—Y plays the queen of hearts, B the knave of clubs, Z the six of spades, A the two of diamonds. *Tricks*—AB, 7; YZ, 4.

Trick 12.—B plays the seven of spades, Z the ace of spades, A the eight of spades, Y the ten of spades. *Tricks*—AB, 7; YZ, 5.

Trick 13.—B makes the queen of spades, and

AB Score Two by Cards and Two by Honours.

Remarks.—*Trick* 6.—If Z trumps with the ace, A discards a spade; and, if Z then leads a trump, AB, with proper play, make 4 by cards.

Trick 10.—Z plays correctly in leading a small spade, as he can count two spades in A's hand and three in B's.

Trick 12.—Z, of course, plays his ace of spades to save the game, as he cannot tell where the queen is.

A's Hand.	B's Hand.
C.—Qn, 10, 4.	C.—Kg, Kn, 9, 6.
D.—Ace, Qn, Kn, 9, 8, 6, 2.	D.—5, 3.
S.—8, 3.	S.—Qn, 7, 5.
H.—7.	H.—Ace, 10, 4, 2.

Y's Hand.	Z's Hand.
C.—7, 3, 2.	C.—Ace, 8, 5.
D.—4.	D.—Kg, 10, 7.
S.—Kg, 10, 9.	S.—Ace, Kn, 6, 4, 2.
H.—Kg, Qn, 8, 6, 5, 3.	H.—Kn, 9.

Chess Column.

By C. D. Locock, B.A.Oxon.

To Correspondents.—Solutions of Problems should be sent in not later than the 12th of each month, for acknowledgment in the following number.

Correct solution of Problem No. 1 received from A. F. Parbury.

C. T. Blanshard.—After 1. B to KB2, R to K5, White cannot mate. See below for correct solution. The problem you send is rather too simple, the move to block the position being obvious. You might, perhaps, puzzle your friends with the following:—White: K at K2, Q at Q2. Black: K at K5, Pawns at K4 and KB4. Mate in 2.

Solutions of Problems.

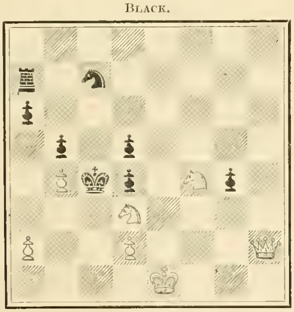
No. 1 (Two-mover, by T. Taverner).—1. R to Rsq, and mates next move.

No. 2 (Fifteen-move Sui-Stalemate, by C. D. Locock).—1. B to B3 ch, 2. Q to B5 ch, 3. R × B ch, 4. Q to K6 ch, 5. P × R (Queening) ch, 6. R to Q6 ch, 7. Q to QR8 ch, 8. Kt to B7 ch, 9. P to Kt4 ch, 10. Q to Kt8 ch, 11. Kt to R8 ch, 12. Q × B ch, 13. Kt to Kt6 ch, 14, Kt to R4 ch, 15. Q to Kt5 ch, K × Q, Stalemate. Blacks moves are all forced.

PROBLEM.

By J. Mortimer.

Black.



White.

White to play, and mate in three moves.

CABLE MATCH.

(Steinitz *v.* Tschigorin.)

We give here the first stage of the "Two Knights Game," with notes.

Two Knights Defence.

White. Steinitz.	Black. Tschigorin.
1. P to K4	1. P to K4
2. Kt to KB3	2. Kt to QB3
3. B to B4	3. Kt to KB3
4. Kt to Kt5	4. P to Q4
5. P × P	5. Kt to QR4
6. B to Kt5 ch	6. P to B3
7. P × P	7. P × P
8. B to K2	8. P to KR3
9. Kt to R3 (*a*)	9. B to QB4 (*b*)
10. P to Q3	10. Castles (*c*)
11. Kt to B3 (*d*)	11. Kt to Q4
12. Kt to R4 (*e*)	12. B to Q3
13. Kt to Ktsq (*f*)	13. P to KB4
14. P to QB3 (*g*)	14. B to Q2 (*h*)
15. P to Q4	15. P to K5 (*i*)
16. P to QB4	16. Kt to K2 (*j*)
17. Kt to QB3	17. B to K3
18. P to QKt3	18. B to QKt5
19. B to Kt2	19. P to B5 (*k*)
20. Q to B2 (*l*)	20. Q × P
21. K to Bsq (*m*)	21. P to B6
22. P × P	22. P × P
23. B × P (*n*)	23. B to KB4 (*o*)
24. Kt to K4 (*p*)	24. B × Kt
25. Q to K2 (*q*)	25. B × B
26. Q to K6 ch	26. K to R2 (*r*)
27. B × Q	27. B × R

(*a*) Up to, and including this move, the line of play was agreed on by the two players.

(*b*) Captain Mackenzie was inclined to prefer 9. . . . B to Q3. White, however, seems to have a good reply in 10. P to Q4. After 9. . . . B × Kt ?; 10. P × B, Q to Q4; 11. B to B3, P to K5; 12. Kt to B3, Q to K4; White wins by 13. Q to K2, which seems better than 13. B to Kt2, the move given by Mr. Steinitz in his *Modern Chess Instructor*.

(*c*) 10. . . . Kt to Q4 would be good, but for the reply 11. B to Kt4. He dare not play 11. Kt to B3, B × Kt; 12. P × B, Kt × Kt; 13. P × Kt, Q to R5, recovering the Pawn. In the above variation, if White play 12. Kt × Kt, Black wins at once by 12. . . . B × P, or, in a more roundabout way, by 12. . . . Q × Kt; 13. B to B3, Q to Q5; 14. B to K3, Q to Kt5 ch; 15. P to B3 (if 15. B to Q2, Q to KR5 wins), 15. . . . Q × KtP, winning another Pawn. Immediately fatal would be 11. Kt to Q2 ? ?, B × Kt; 12. P × B, losing the Queen.

(*d*) 11. P to QB3 also presents claims to consideration. Not so, however, 11. B to K3, for Black would exchange both pieces and proceed with Kt to Q4, threatening Q to R5 ch, or Q to Kt3, according to circumstances.

(*e*) 12. Kt × Kt, besides presenting Black with a centre, would allow his QKt to escape at QB3, bringing the game to a kind of Evans Gambit position.

(*f*) In view of the adverse KBP coming on, he no longer relishes the idea of B × Kt, a capture which would have been obviously imprudent on the previous move, on account of 13. Kt × B, B × P ?; 14. R to Ktsq, &c.

(*g*) A characteristic move (*vide* note (*i*)). After 14. P to Q4, P × P; 15. Q × P, Black, according to Mr. Steinitz, has a good game. He might continue 15. . . . Q to K2, preventing Kt to B5, and threatening 16. . . . Kt to Kt 5, and other terrors.

(*h*) A very ugly-looking move. B to K3 has, at any rate, a more attractive appearance (*vide* move 17).

(*i*) Hear now the Master: "If Black had played P × P, I should have retaken with the Pawn, creating two 'holes' in Black's game at K4 and QB4." So isolated Pawns are not so bad always after all! In this case the compensation partly lies in the open QB file.

(*j*) Mr. Steinitz would probably answer B to Kt5 ch? by K to Bsq, or Kt to B5 by B to Bsq.

(*k*) A little premature, perhaps. He might play instead 19. R to Ktsq, preventing P to QR3. If then 20. P to KB4, Black might venture . . . P to KKt4, followed by Kt to

Kt3. 20. . . . Kt to Kt3 at once would be useless on account of 21. P to Kt3, and if Black sacrifices the Knight the White King escapes to QB2. Mr. Tschigorin's object, no doubt, was to prevent P to KB4, even though that move would give him a passed Pawn.

(*l*) A very fine move, if properly followed up. Black is practically bound to take the offered Pawn, or White could Castle (against his principles) on the Q side.

(*m*) "Steinitz's Delight." Moreover it threatens to win a piece by P to QR3. At the same time, with all due deference, it is difficult to describe it (followed up as it is) otherwise than as an extraordinary blunder, occurring as it does in a correspondence game. White might have obtained the superiority by the following simple line of play: 21. P to QR3. B × Kt (forced); 22. B × B, Q to Kt3! (If Q to Qsq, White wins a piece by Q × P and Q to K5); 23. Q × P, P to B3!; 24. P to QKt4, Kt to Kt6; 25. R to Qsq, followed by Kt to R3.

(*n*) If 23. Kt × P, B to R6 ch; 24. K to Ksq, with a good enough game. Black is still a Pawn to the bad, and his attack is, to say the least, not obvious.

(*o*) The best, and in fact the only move, as White threatens P to QR3 followed by Kt to K4.

(*p*) Another extraordinary blunder. Q to Bsq was the only move. B to K4 would obviously lose a piece. The same result would attend Q to Qsq, on account of the reply B to Q6 ch.

After 24. Q to Bsq, B to Q6 ch (better than B to R6 ch, to which White could reply 25. K to K2); 25. QKt to K2!, Q to R5; 26. Q to K3, with a good game.

It should be noticed that 25. K to Kt2 was out of the question on account of the winning reply R × B! 25. K to Ksq was also dangerous in view of QR to Ksq. (Not, however, 25. . . . R × B; 26. Kt × R, Q to K5 ch; 27. Q to K3, Kt to B4; 28. Q × Q, B × Q; 29. K to K2 and wins).

(*q*) He perceives now, what he must have overlooked at move 21, that 25. B × B would lose on account of 25. . . . R × P ch!; 26. Q × R, Q × B; 27. Kt to B3, R to KBsq; 28. K to Kt2, B to B4!; 29. Q to Kt3, Q to B7 ch, &c.; or, better still, 29. . . Kt. to B4. Mr. Tschigorin, of course, takes advantage of the move actually made, to give up his Queen for more than an equivalent both in material and position.

(*r*) A learned commentator in an unlearned contemporary suggests here 26. . . . K to Rsq, as leaving the King less subject to checks. He would be subject, however, to a mate in two moves, which White might announce after 27. B × Q, B × R.

After the next move on each side the game enters on a new phase, the consideration of which, in view of the alphabet running short, is postponed till the conclusion of the game.

The following additional moves have been made in this game:—

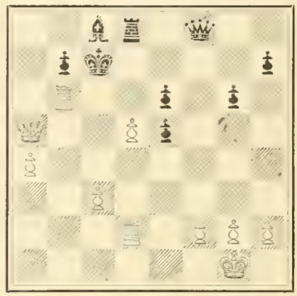
WHITE.	BLACK.
28. Q to R3!	28. Kt to B4
29. B to K5	29. QR to Ksq
30. B to B4	30. Kt to Q5
31. Q to Q3 ch	31. B to K5
32. Q × Kt	32. R × B
33. P to B3	33. QR to KBsq
34. Q × RP	34. P to B4
35. Q to QB7	35. Kt to B3
36. P to QR3.	36. R × P ch!
37. Kt × R	37. R × Kt ch

The Evans Gambit game has been continued as follows since the publication of the diagram in the March number:—

WHITE (Tschigorin).	BLACK (Steinitz).
21.	21. B to Q3
22. Kt to R4	22. Kt × Kt
23. Kt to B5	23. P to KKt3
24. Kt × B	24. Q × Kt
25. B × Kt	25. BP × B
26. B × P	26. R to QRsq
27. Q × R	27. Q × B
28. Q to R4	28. K to Qsq
29. R to Q2	29. K to B2
30. R to Ktsq	30. R to Qsq
31. R to Kt5	31. Q to B3
32. Q to Kt4	32. P to Q3
33. P to QR4	33. Q to Ksq
34. R to Kt6	34. Q to Bsq
35. Q to R5	35. P to Q4
36. P × P	

(*Present Position*).

BLACK.



WHITE.

The news of the death of Captain G. H. Mackenzie has been received in England with the greatest regret. Besides being for a great many years the strongest player in America, Captain Mackenzie was perhaps the most universally popular of all the chess masters. As a player he takes rank only after Mr. Steinitz and the late Dr. Zukertort.

CONTENTS OF No. 66.

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CONTENTS.

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STELLAR SPECTRA.

[*Second Paper.*]

By E. W. MAUNDER, F.R.A.S. (*Assistant superintending the Spectroscopic Department of Greenwich Observatory*).

THE last paragraph of my paper on this subject in the April number of KNOWLEDGE was cut abruptly short, and would bear further explanation, and the Editor having courteously invited me to resume the subject, I accordingly do so.

The method of comparing the mass-brightness of double stars, which Mr. Monck devised (*Observatory*, vol. x., p. 96), depends upon the circumstance that the period of a binary is not affected by its distance from us, and though its mass will vary according to the distance from us which we assign to the star, its total brightness will vary in the same proportion. Given then for two pairs of double stars the apparent brightness, the apparent angular radii of the relative orbits of the two components, and the periods of each, and their relative mass-brightness—or to use Prof. Young's more graphic phraseology, their relative "candle power per ton"—can be computed. The formula only breaks down in the improbable case of a pair in which one star is at once very much fainter, and yet nearly as heavy as the other.

The following table shows the values of the relative mass-brightness of the stars of the two types as given by Mr. Gore in his "Catalogue of Binary Stars":—

SIRIAN STARS.

OΣ 4	1·48	ω Leonis	4·06	ξ Scorpii	5·70
OΣ 20	9·77	φ Ursæ Maj.	21·26	λ Ophiuchi	29·51
14 Orionis	4·09	γ Virginis	4·92	μ Draconis	4·21
12 Lyncis	14·01	25 Can. Ven.	7·28	ζ Sagittarii	23·04
Sirius	6·35	η Coronæ Bor.	1·40	δ Cygni	31·29
Castor	38·12	μ^2 Bootis	2·74	β Delphini	6·85
ζ Cancri	2·90	γ Coronæ Bor.	22·10	λ Cygni	11·01

SOLAR STARS.

Σ 3062	0·68	42 Comæ	2·46	Σ 2173	0·88
η Cassiopeiæ	0·33	Σ 1757	0·37	τ Ophiuchi	7·35
36 Andromedæ	6·23	Σ 1819	0·95	70 Ophiuchi	0·30
Σ 228	1·17	α Centauri	1·31	γ Coronæ Aust.	1·22
OΣ 149	1·07	ξ Bootis	0·34	OΣ 387	2·46
Σ 1037	1·83	44 Bootis	2·07	OΣ 400	3·07
Σ 3121	0·21	OΣ 298	0·45	4 Aquarii	3·64
ξ Ursæ Maj *	1·00	σ Coronæ Bor.	1·77	τ Cygni	4·28
OΣ 234	1·80	ζ Herculis	4·67	π Cephei	11·07
OΣ 235	2·11	Σ 2107	1·74		

* Mr. Monck employed this binary as his unit of comparison.

The table shows two striking features. First, an *average* superiority of the Sirian over the Solar stars, far too marked and too frequent to be the effect of accident, for whilst the mean mass-brightness of the First Type stars is 12·00, that of the Second Type is not one-fifth so great, being only 2·30. Indeed, one-third of the Sirian stars are brighter per mass unit than the brightest Solar star, and one-half the Solar are fainter than the faintest Sirian. So that we cannot resist the conclusion that, in proportion to their light-giving power, stars resembling our own sun in spectrum are considerably heavier, and if we assume a uniform brilliancy for equal photospheric areas, much denser than those like Sirius or Vega. But when we take this conclusion in connection with the one already arrived at, that the total light-giving power of the average member of the Second Type is greater than that of the First, the superiority in mass of the Solar stars becomes yet further enforced. If it be legitimate to ascribe the title "giant suns" to any one of the classes into which we divide stars, as distinguished by their spectra, then undoubtedly it must be the Solar and not the Sirian stars which must be so designated.

But the second conclusion to be drawn from the table would show that spectrum alone, at least as at present classified, is insufficient to determine whether the mass-brightness of a star is relatively high or low. Just as with the table given on p. 73, stars of every degree of absolute light-giving power were found in either type, so it is now with mass-brightness. We could not then suppose that any given dimensions, or any given total-light radiation, were necessarily associated with a particular form of spectrum; and so now we are precluded from supposing that any given degree of condensation corresponds to the one type or the other.

This conclusion has a more important bearing on the question of the "Age of Stars" than the former; using the word "age," of course, not to signify actual length of

existence, but condition of development. For whilst the total light-giving power of a star will depend not merely on its "age," but also on its size, so that we might expect both "old" and "young" stars to show a great diversity of emissive power, it is not so with its conditions of condensation. On the current theory of gradual cooling and contraction the mass-brightness would vary directly with the "age," and we should expect, if spectrum type simply meant stage of development, that there would be no very wide range of difference of mass-brightness in any particular class, but that different types would be clearly marked off from each other by very different brilliancies per unit of mass. It should be as easy to assign its spectrum to each star in the table, from a consideration of the number deduced for it, as from actual scrutiny by the prism. That the fact is so different shows that we cannot accept such speculations as those of Vogel and Lockyer as holding good generally; spectrum type may mean "age" in a number of instances, but it cannot always do so.

So far as the spectrum is an indication of the stage of development attained it will undoubtedly be true, as I said in April, that "theorists are probably right when they have placed the Second Type stars as belonging to a later stage than the First"; but we must bear clearly in mind that we have no right to assert that all stars, or even the majority, pass through both stages.

One most notable exception to the general greater density of the Second Type stars must be mentioned. This star, γ Leonis, with a relative candle power per ton of 92·99, stands out so distinguished for its superiority of brilliancy over mass that I have not included it amongst the other Second Type stars in the table. I think we are warranted in treating this star, the co-efficient of which is half as large again as all the other 29 stars of its type put together, as altogether exceptional. Nevertheless, its inclusion with the other members of the type would not have materially altered the result. The average First Type star would still have shown a higher mass-brightness than the Second Type, whilst it would have become more, and not less, obvious that condensation alone was not a sufficient indication of spectrum.

It is possible that the explanation of this peculiarity of γ Leonis may be that the Second Type is a stage passed through twice, once during the period of increasing temperature, and later, after the First Type has been gone through, during the time of decline. At present, however, the star stands quite alone, and the only star which can reasonably be suggested as also showing a similar extraordinary relative brightness is Arcturus. If Arcturus emits 147 times as much light as Sirius, it seems easier to suppose that this corresponds to a greater emissive power per ton, than to take the reverse view and assign it say 500 or 600 times the mass of Sirius.

It would be an immense assistance to us in an enquiry of this nature if we knew the details of the spectra of both members of a large number of pairs. Unfortunately, there are special difficulties about the examination of the spectra of double stars, and, in consequence, it is a branch of study which has been left practically untouched. We have, however, many records of the *colours* of binaries, and, in default of direct spectroscopic observation, they may be of some service. Now these give us a most noteworthy result. Where the two components of a binary are equal, or nearly so, then both are nearly of the same colour likewise. Where one is much smaller than the other, then in the great majority of cases the larger is yellowish, the smaller blue. The blue star is *never* in such a case the larger. Thus Mr. Lockyer gives, in his "Meteoritic Hypothesis," tables of 120 binary stars, from Mr. Chambers' revised "Bedford Catalogue." Of these 120 stars, the colours of the companion are not given in 5 cases, leaving 115 to work with. Of the 115, 55 pairs show the same colour—nearly always white to yellow—and the mean difference in brightness is less than one magnitude, and never exceeds two. In 30 cases, the principal star is white to yellow, and the small star blue, and for this class the mean difference of brightness is two magnitudes; and in 21 other cases the same arrangement of colours prevails, but the mean difference of brightness is six magnitudes. Five pairs only show the large star white or yellow, and the small star red.

The natural tendency would be to interpret the yellow stars as being probably of the Solar Type, as many of them certainly are, and the blue or purple stars as strongly-marked specimens of the Sirian Type. Mr. Lockyer does so, and so does M. Rocques in a recent paper on the "Age and Colour of Stars." In one instance at least we know that this interpretation is a correct one, and though it is very likely that some of these small deeply-coloured stars have spectra of a type as yet unrecognised, yet the assumption that many are Sirian in character is an extremely probable one.

If so, four independent methods result in showing us the Solar stars as on the average larger than the Sirian. First, the Solar stars are represented in a higher proportion amongst the third and fourth magnitudes than amongst the sixth and seventh. Next, amongst stars of which we know the parallax, the Solar stars prove to have the highest total light-giving power. Thirdly, the mean mass relative to the light-giving power is much greater for Solar stars. And now we see that when the two components of a pair are nearly equal they agree in colour, but when unequal, then the smaller would appear to be of the Sirian, the larger of the Solar Type.

It seems to me that this curious subordination of the blue stars in binary systems points to the principal star having amassed to itself the bulk of the metallic constituents of the nebula from which the system sprang; or else, if we adopt the idea of fission recently put forward by Herr See, that the smaller body when thrown off consisted mainly of the lighter elements, the heavier remaining in the principal star. In other words, in these cases spectral type depends upon original chemical constitution, and not upon the stage of stellar development attained.

A further circumstance which looks in the same direction is the marked crowding of particular types in special regions. Prof. Pickering has pointed out that whilst the Second and Third Types are pretty evenly divided between the Galactic and non-Galactic regions, two-thirds of the First Type stars are found in the Milky Way, whilst the Fourth Type stars notoriously affect Birmingham's "Red Region," in and near Cygnus. Then again, the stars with spectra resembling those discovered by Wolf and Rayet, *all*, though they are 33 in number, lie within 10° of the Galactic equator, the great majority within 2°. The Orion stars—except Betelgeuse—again have a type of spectrum of their own, scarcely found outside the limits of the constellation. It seems only natural to infer that these remarkable instances of unequal distribution of stars of particular types are due not to the prevalence of one particular evolutionary stage in certain districts, but to a similarity in actual composition.

Nevertheless, it will not do to entirely discard the idea of successive stages, as evidenced by the different spectral types. The table on previous page shows this. If type had never anything to do with age, it is hard to see why there should be such a marked superiority in mass-bright-

ness of Sirian over Solar stars. Then again, the complete gradation observed, not a shade of difference missing, from Sirius down to stars like Mira Ceti, or α Herculis, is a strong argument in favour of an historic as well as a chemical interpretation of spectral peculiarities. But I would urge that this supposed course of evolution need not be universally operative, it is not necessary that every star pass through every stage. It is, perhaps, not necessary that any one star passes through all. But just as we may suppose that in a typical star, successive conditions of temperature and condensation bring up into the "reversing layer" at one epoch hydrogen, at another magnesium, at a third the substances, whatsoever they be, that cause the beautiful bands which Mira shows; so in the wider evolution of a multiple system, or wider still, of the entire Galaxy, certain stars, certain districts may become richer than the rest in this or that element, to be poorer in others; so that they have, as it were, a special stage indelibly imprinted on them. Thus they may present the appearance of a given epoch without ever having passed through the one theoretically considered as preceding it, and without the possibility of their ever entering on the phase supposed to be the next.

To sum up. The Types of Stellar Spectra are not to be explained along one line only, but along two; they do not always denote the phases attained by the stars in their development; they often indicate instead, radical differences of constitution. But when they have the first, the historical significance, the Solar usually denotes a later epoch than the Sirian; possible exceptions being seen in the cases of γ Leonis and Arcturus. And on the average the Solar stars and not the Sirian are the brightest, and have the greatest masses, though they are inferior to the latter as to relative brightness per unit of mass.

THE ORIGIN OF THE CHALK.

By John T. Kemp, M.A.Cantab.

The origin of the Chalk is a question which, though it has been long under discussion, is not by any means satisfactorily settled. The early investigators were much puzzled through being unable to find any rock at all resembling it in process of formation at the present time. Its extreme freedom from clayey or sandy material led them to regard it as a deep-sea deposit; and, hence, upon the discovery of the Grey Ooze of the Atlantic Ocean, it was concluded, somewhat hastily perhaps, that it must be the missing analogue. Some writers even went so far as to maintain that we were still living in the Chalk age. The argument was supported not only by the occurrence of similar species of foraminifera and other lowly organisms in the two deposits, but by certain resemblances in their higher fauna. Sponges which abound in the Ooze are closely allied to the siphonias and ventriculites of the Chalk. Echinoderms are common in both. *Echinothuria*, a genus characterized by the possession of a flexible covering, and peculiar to the Chalk, finds its nearest living representatives in the deep-water forms, *Asthenosoma* and *Phormosoma*. A species of *Beryx*, a well-known genus of fishes from the Chalk, has also been found in the Ooze.

That the Chalk was not formed under precisely the same conditions as the Atlantic Ooze appears now to be quite certain, but whether the differences are sufficient entirely to upset the older theory is still a matter of dispute.

One of these differences is in the chemical composition of the two deposits. Whereas the Chalk is composed of *98 or 99 per cent. of carbonate of lime with a little silica and alumina, the Ooze only contains from 41 to 80 per cent. of carbonate of lime, with 5 to 8 per cent. of silica, and from 8 to 33 per cent. of alumina. In these analyses it must, however, be remembered that in the Ooze every constituent is taken into account, while in the Chalk no notice is taken of the flints which contain the greater part of the silica. Prof. Prestwich estimates them at from 4 to 6 per cent. of the whole mass. The difference in the average amount of silica, if any, is, however, so slight that, taken by itself, it does not militate against the similarity as to origin of the two deposits.

The high proportion of alumina in the Ooze, as compared with the Chalk, presents at first sight a greater difficulty to the acceptance of the older theory. Its abundance in the former deposit is undoubtedly due to mechanical causes, for only the slightest traces of it are present in solution in sea-water, and it is never secreted by living organisms, as silica and carbonate of lime are. This difference in composition is nevertheless compatible with close similarity of origin. For, supposing that other appearances all pointed in that direction, this one exception might easily be explained on several hypotheses, such as the subsidence of suspended material from the land before reaching the Chalk area owing to great distance or slowness of currents; or secular variations in the amount of meteoric, volcanic, or other kinds of dust falling upon the sea.

It is when we come to examine the stratigraphy of the Chalk more carefully, and to compare its fauna more closely with the fauna of the Atlantic Ooze, that we find the most cogent reasons for doubting their likeness of origin.

The White Chalk, as distinguished from other Cretaceous deposits of the same age, is confined to an area stretching from Britain and Northern France through Holland, Northern Germany, Southern Sweden, and Southern Russia to the Crimea and the Ural Mountains. On the older rocks around this region beach-lines have been discovered at various levels, while throughout the Chalk eroded surfaces are frequently met with, accompanied by changes of life. One of these breaks, or unconformities, occurs at the base of the zone† of *Micraster cor-testudinarium*, another separates that zone from the zone of *Micraster cor-anguinum*, while a third precedes the incoming of the Danian stage. There are also various others. The nearness of the coasts and the frequency with which the sea-bed was brought within the sphere of denuding action by earth movements are strongly indicative of shallow water.

The palæontological evidence on the whole strongly confirms this view, notwithstanding, as has already been stated, some apparently adverse facts.

The late Dr. Gwyn Jeffries finds that the seventy-one genera of Mollusca known in the Chalk are all forms whose closest existing allies inhabit comparatively shallow water, while the genera characterizing the Ooze are very rare or altogether wanting in the older formation. Brachiopoda and Cephalopoda, so abundant in the Chalk, have been shown by the "Challenger" dredgings to be very uncommon in the Ooze. Although Echinodermata are frequent, they are (like the Mollusca) mostly of small size, and but distantly related to the Cretaceous forms.

The Atlantic Ooze is evidently of exceedingly slow growth, while the Chalk, on the contrary, appears, from the

* This applies to the pure white Chalk only; the Chalk marl contains a much larger percentage of other matter.

† These "zones" are vertical sub-divisions of the Chalk characterized by the presence of particular species of fossils which are rarely, if ever, found at higher or lower levels. *Micraster* is a genus of sea-urchins.

state in which many of its remains are preserved, to have accumulated with considerable rapidity. Fishes are found with their scales undisturbed, cidarids with their spines *in sitû* and so forth, showing that they were entombed in material solid enough to support them before the destruction of their soft parts was accomplished. There is also reason to think, from the absolutely amorphous state of much of the calcareous matter, that some of it was of chemical or mechanical origin; that is, it is either a precipitate from solution or else detritus from pre-existing limestones. Dr. Sorby considers it impossible for calcite shells to form such a substance by their destruction, though aragonite ones may do so.

Such are the principal arguments which have been adduced in denial of the theory that the Chalk was an earlier equivalent of the Atlantic Ooze. If, as geologists are becoming more inclined to hold every day, that theory is untenable, what shall we put in its place?

According to Dr. A. R. Wallace, conditions almost identical with those under which the Chalk was formed exist at the present time in the northern part of the Gulf of Mexico. The researches of Pourtales show that the ocean bed is there covered with a fine white mud, closely resembling Chalk in composition, and which consists chiefly of the impalpable detritus of the coral-reefs which fringe the numerous islands, together with the skeletons of the foraminifera abounding in the warm waters of the region. Coral-reefs exist in the Chalk of Maastricht and Faroe, but with these exceptions they are almost unknown in the formation.

Prof. Prestwich also discusses the subject at considerable length in his "Geology." He thinks that much further investigation will be required in order to set the question at rest. In the meantime, he is of opinion that the Chalk was formed under conditions which have passed away, or at any rate are nowhere exactly realised at the present time. The stratigraphy indicates that it was deposited in a nearly enclosed sea of no great depth. The rivers flowing into this sea brought down a very exceptional amount of soluble silica, though not so much as in somewhat earlier times: some of the Upper Green-sand beds contain as much as 72 per cent. In the presence of solid silica (of which sponge spicules, &c., are made) or of organic matter, this substance was precipitated, and formed the flints which so often enclose remains of sponges, or occupy the tests of echinoderms.

WHAT IS THE CAUSE OF VOLCANIC ACTION?

By Rev. H. N. Hutchinson, B.A., F.G.S.

In our previous paper we endeavoured to explain the structure of a Volcano, and described briefly the chief phenomena of an eruption. "Is it possible," the reader may ask, "to form any conclusions as to how volcanic eruptions are brought about?"—in other words, to find out what is going on underneath, and so to obtain some idea of the cause or causes of these strange manifestations of subterranean activity. It must be confessed at once that, in the present state of scientific knowledge, no full and complete explanation is possible. Geologists and others are as yet but feeling their way cautiously towards the light which, perhaps before long, will illumine the dark recesses of this mysterious subject; but nevertheless, since volcanic action was first carefully studied by Mr. Scrope, Sir Charles Lyell, and others, such valuable material has been collected, that we are getting much nearer to a true theory now that the ground has been somewhat cleared. Others, among living geologists, have carried on researches of very great value, and so have thrown valuable light on the subject. It will, perhaps, hardly be necessary to point out that the main difficulty is our ignorance of the interior of the earth. If we could penetrate subterranean regions to a sufficient depth, and find out the physical conditions prevailing far below the surface, there would be little difficulty in finding out how Volcanos are worked. But since direct knowledge is impossible, the problem must be attacked indirectly. We are somewhat in the position of a medical man diagnosing a difficult case; only medical science has the great advantage of knowing accurately the internal structure of the human body. The earth, unfortunately, is a body the internal anatomy of which is unknown. Of its epidermis, or skin, we have learned a good deal, but beyond that all is speculation. Looking upon volcanic action as a curious disease from which our patient the world occasionally suffers, it may not be unprofitable to see if some rough sort of diagnosis of the case is possible.

For this purpose it will be necessary to consider volcanic action a little more generally. We must not confine our attention to any one outbreak of the disease, or to any one Volcano, but look at the subject as a whole, putting ourselves, as it were, in the position of the physician who judges of any one "case" from the experience he has derived from the study of a great many "cases."

Now the first thing to remark is that volcanic action goes through phases, of which there are three. First, there is the state of permanent eruption—this is not a dangerous state, because the steam keeps escaping all the time the safety-valve is working, and all goes on smoothly. The second state is one of moderate activity, with more or less violent eruptions at brief intervals—this is rather dangerous; the safety-valve is at times jammed. And thirdly, we have paroxysms of intense energy alternating with long periods of repose, sometimes lasting for centuries. These eruptions are extremely violent and cause widespread destruction; the safety-valve has got jammed and so the boiler bursts. No Volcano has been so carefully watched for a long time as Vesuvius. Its history illustrates the phases we have just mentioned. The first recorded eruption is that of A.D. 73, a very severe one of the paroxysmal type, by which the towns of Herculaneum, Pompeii, and Stabiæ were buried up. We have an interesting account by the younger Pliny, whose uncle lost his life through remaining too near the scene of action, partly for the sake of rescuing those in danger and partly because he wished to observe the strange phenomenon. Before this great eruption took place Vesuvius had been in a quiescent state for 800 years, and if we may judge from Greek and Roman writings was not even suspected of latent possibilities in the way of volcanic eruptions. Then followed an interval of rest till the reign of Severus, the second eruption taking place in the year 203. In the year 472, says Procopinus, all Europe was covered, more or less, with volcanic ashes. Other eruptions followed at intervals, but there was complete repose for two centuries, *i.e.* until the year 1306. In 1500 it was again active, then quiet again for 130 years. In 1631 there came another paroxysmal outburst. After this many eruptions followed, and they have been frequent ever since. Vesuvius is, therefore, now in the second stage of moderate activity.

But geologists can take a wider view of Volcanos than this; their researches into the volcanic action of remote geological periods have yielded important results, which may be briefly indicated here. They can sum up the history of a volcanic region, and the result seems to be somewhat as follows:—There is a regular cycle of changes;

the invasion of any particular area of the earth's surface by the volcanic forces is heralded by subterranean shocks causing earthquakes. A little later on, fissures are formed, as indicated by the rise of saline and thermal springs, and the issuing of carbonic acid and other gases at the surface of the earth. As the subterranean activity becomes more marked, the temperature of the springs and emitted gases increases, and at last a visible rent is formed, exposing highly heated and incandescent rocky matter below. From the fissure thus formed, the gas and vapours imprisoned in the incandescent rocks escape with such violence as to disperse the latter in the form of scoriæ and volcanic ash, or to cause them to pour out in streams or lava flows. The action generally becomes concentrated at one or several points along the line of action—that is, the line of fissure and dislocation. In this way, a chain of Volcanos is formed, which may become the seats of volcanic action for a long time. When the volcanic energies are no longer able to raise up the fluid materials so that they shall flow out of the cones which have been built up, nor to rend their sides and form parasitic cones, fissures with small cones may be formed in the plains around the great central Volcanos. Later on, as the heated rocky matter below cools down, the fissures become sealed up by consolidating lava, and the Volcanos fall into a condition of quiescence, after which they begin to suffer from the effects of exposure to the atmospheric agencies of decay, and thus become more or less worn away or "denuded." But still the existence of heated rocky matter at no great depth below is indicated by outbursts of gases and vapours, the formation of geysers, mud-volcanoes and ordinary thermal springs; gradually, however, even these manifestations become more feeble, and thus all visible signs of volcanic energy die away in the district. Such a cycle of changes may require millions of years, but by the study of Volcanos in every stage of their growth and decline, it is possible to reconstruct this outline of their life history.

That Volcanos are built up along lines of fissure in the earth's crust does not admit of any doubt. The present distribution of Volcanos over the earth is a striking proof of this, and, moreover, we have further evidence derived from the study of old volcanic areas, which have been, as it were, dissected and so brought to light by long-continued erosion or denudation. Let us look a little more closely at the present distribution of Volcanos on the earth's surface, for it reveals some interesting facts which must be borne in mind in forming any conclusions with regard to the possible cause of volcanic action. One rule we have already observed, viz., that Volcanos are mostly distributed along lines. Secondly, they seem to follow or coincide with great mountain chains, such as the Andes, Rocky Mountains, or the ranges of Central America. Thirdly, there is some kind of connection between Volcanos and the coast lines of continents. Fourthly, they are always near some body of water (*i.e.*, when in the active stage). Fifthly, they are situated in regions of the earth which are undergoing slow upheaval, and are absent from regions where subsidence is taking place.

In framing any conclusions with regard to the problem under consideration, we must remember that volcanic action depends mainly on two things—(1) a high temperature below the region of activity, (2) the presence of steam at a high pressure.

Superheated steam evidently plays a very important part, and the force which raises masses of molten lava to the surface may be that due to the expansive power of steam. Volcanic eruptions, then, are essentially gigantic explosions, such as are faintly imitated in the bursting of steam boilers. This is good as far as it goes, but we cannot take it as an explanation of volcanic action; for we require to know the source of the steam, and of the lava, as well as the reason for the high temperature necessary for the production of both. Where does the heat come from? and what is the source of so much steam? Sir Humphry Davy, discoverer of the metals of the alkalies and alkaline earths at the commencement of the present century, showed that the metals potassium and sodium when touched by water develop a great deal of heat; in fact they burn on water, decomposing it and uniting with the oxygen. This led him to throw out the idea that if pure metals exist far down in the earth's interior, the access of water and air might give rise by oxidation to a large amount of heat, sufficient in fact to produce volcanic phenomena. But later on he confessed that this chemical theory of Volcanos was unsatisfactory. If it were true, enormous quantities of hydrogen gas would necessarily be emitted during volcanic action, but this is not the case.

It will readily be perceived that all explanations of volcanic action resolve themselves finally into the question of the condition of the earth's interior, with regard to which we can at present only speculate; hence the absence of any complete and consistent explanation of the volcanic problem.

Certain facts undoubtedly tend to establish the idea, once firmly maintained, that the whole of the earth's interior is in a highly heated state, but they do not prove it. The well-known increase of temperature as we descend mines, which is about 1° F. for every 50 or 60 feet, is not sufficient proof, for the *rate of increase* does not seem to be maintained as we descend to the greatest depths, and it is possible that the centre may be cold.* Still, astronomers tell us that the earth has been for ages a cooling globe, so that it would seem natural to suppose that there are still vast stores of heat within; but they may be more or less local.

It has even been argued, at one time, that the whole interior of the earth is in a molten condition, with only a thin crust of solid matter forming a kind of shell or outer

* It is conceivable, though it is not probable, that the central portions might not be warmer than the regions which have been already explored; but it is impossible that, after the lapse of ages, they should remain cooler than the exterior layers. The sun was formerly supposed by Bode, Sir John Herschel, and other distinguished astronomers to be a cool body surrounded by two atmospheres, the inner one a partially opaque heat-absorbing atmosphere, and the outer *photosphere* a brilliant heat-giving atmosphere. If it had not been for the great desire which mankind has always had to suppose that other bodies are inhabited by beings similar to ourselves, such an idea would probably never have been entertained. Sir Isaac Newton considered and rejected the theory that the sun might have a cool body and yet be surrounded by a hot atmosphere. But his reasons were only given in a letter, and were probably not generally known till the middle of this century. They are so clearly expressed that they could not fail to have convinced any intelligent thinker. The letter of Sir Isaac Newton I refer to was published by Sir David Brewster in his Life of Newton, Vol. II., p. 455. Sir Isaac says, "Though the inward part of the sun were an earthy gross substance, yet if the liquid shining substance Mr. Flamsteed supposes to swim upon it be then hot, it will heat the matter within it as certainly as melted lead would heat an iron bullet immersed in it. Nor is it material whether the liquid matter on the sun be of any considerable thickness. An iron bullet would heat as fast in a quart as in an ocean of melted lead, this difference only excepted, that the bullet would cool a small quantity of lead more than a great one. If, then, the liquid matter swimming on the sun be but so thick as not to be cooled by the central (as it must be), it will certainly heat the central parts, for it imparts heat to the contiguous parts as fast as if it were thicker, by which means the central parts must become as hot as if the hot fluid matter surrounding it equalled the whole vortex. The whole body of the sun, therefore, must be red hot, and consequently void of magnetism, unless we suppose its magnetism of another kind from any we have." A. C. Ranyard.

coating; but this doctrine of a thin crust has been abandoned on account of strong evidence telling against it. It is quite possible for the earth's interior to be highly heated and yet to remain in the solid state. The enormous pressure to which rocks lying below the earth's crust (a word still retained for convenience sake by geologists, but without at all implying a fluid state below) must be subjected may be quite sufficient to prevent their fusion, for pressure probably retards the melting of solid bodies as it does the converting into vapour of liquids. Sir William Thomson proved that if any large portion of the earth were liquid, or viscid, or even as elastic as a sphere of steel, it would rise and fall as the ocean does under the influence of the sun and moon, and thus produce tides which would considerably interfere with the tide of the ocean as we now observe it; for it is clear that, if the land rose and fell at the same time as the ocean, the one would obscure the other. There is, possibly, a slight tide in the earth, but only such as would be caused in a very non-elastic body; whereas with a fluid interior the crust would rise up and down considerably, and would partly hide or very considerably interfere with the tide we perceive in the ocean. Some geologists maintain that there may be a great solid nucleus, with a thin liquid layer over it, and a solid outer layer or crust; but there are some difficulties in the way of this theory which cannot be considered here.

Let us assume, however, that the lower regions of the earth are in a highly heated state. Calculating from the observed rate of increase of temperature on descending, it is concluded that at a depth of 50 miles below the surface there may be a temperature of 2000° C.—sufficient to melt even platinum (at the surface); and, further, let us suppose such a temperature to be due to the earth having once been in a molten condition (according to the nebular theory). We have got, then, our source of heat; let us see what use we can make of it. Some geologists would explain volcanic manifestations in this way. Vast quantities of sedimentary matter slowly accumulate on the floors of seas, in time forming great deposits of stratified rock, thousands of feet thick; as the materials accumulate the bed of the sea slowly sinks under the weight of all this material. The accumulation of so much rocky matter checks the flow of the earth's heat, and so raises the temperature of that region, thus acting as a bandage does on the human body. Such sedimentary deposits necessarily contain much water — probably as much as from 5 to 20 per cent. of their mass. As the strata sink, and as the earth's heat rises up to them, their imprisoned water may be raised to a temperature far above its ordinary boiling point. Streams of molten rock penetrate their mass, and generate more steam, or at least highly heated water, and in this way possibly a large amount of the sedimentary material might be melted into lava, and such lava, with its occluded steam, would be sure to find its way up through any lines of weakness in the overlying rocks (such as fissures, faults, &c.), and on reaching the surface would give rise to volcanic action. There is a good deal to be said in favour of this explanation, for it accounts for the steam which plays so important a part. But it leaves out of sight some other aspects of the question. Others accounted for the steam by the observed proximity of active Volcanos to bodies of water. They argued that the water penetrating by infiltration through the floor of the sea, found its way to highly heated masses of rock, and was converted into steam, which would find its way up through any fissures which the stratified rocks above might contain. This theory seems to harmonize well with some of the facts, but after what has been said it will not be necessary to go out of our way to account for the presence of the steam. Some geologists are inclined to believe that here and there, below the earth's surface, there may be local reservoirs of still molten matter, and that these are the supplies from which the lava flows come, but this idea fails to account for the association of Volcanos with mountain chains, and with seas, as well as other important facts. A much more promising explanation is that there are below the crust of the earth large masses of highly heated rock, *kept solid* by the enormous pressure of overlying rocks; but that when earth-movements taking place within the crust, such as the upheaving of mountain chains, take off some of the weight, the balance of pressure is no longer maintained, and so these highly heated rock masses run off into the liquid state, and find their way to the surface, producing volcanic action. There is much to be said in favour of this view. It rightly connects volcanic action with movements of upheaval, with mountain chains, and lines of weakness in the earth's crust.

Now, the rocks in mountain chains are found to have suffered considerably from the effects of heat and pressure, and are seen to be considerably altered from their original state. Shales and sandstones have been converted into slates and quartzites, or even into schists and gneiss, and in some cases into granite; so that metamorphism, as it is called, seems to be closely connected with the upheaval of mountain chains, the crumpling and folding of rocks, which is very conspicuous in mountains, and with outbursts of volcanic energy.

The late Mr. Louis Mallet put forward a very ingenious speculation which seemed to explain all these coincidences. He endeavoured to show that the earth's supposed internal heat might be dispensed with altogether, and that the earth-movements themselves would be able to produce all the heat required for volcanic action. Friction, we know, produces heat, and he argued that the enormous friction involved in the crumpling, crushing, folding, and displacing of large masses of rock would be sufficient to bring about the melting of portions here and there, and that volcanic action would follow wherever these reached the surface. The theory has attracted much attention, and was very ably worked out; but his experiments on the amount of heat developed by the crushing of small portions of rock were not quite satisfactory. That some amount of metamorphism is due to the heat produced by friction, and the crushing of rock during earth-movements may be readily granted, but it would be rash to assume more than this. We do not yet know at what rate these Titanic forces of mountain building work, and so any speculations as to the temperatures developed by friction must be rather vague. The theory, however, did good service in attempting to explain the close connection between phenomena which had previously been looked upon as in no way connected with each other. Its simplicity and comprehensiveness were much in its favour.

But it seems like going out of our way to find a source of heat. If the earth is still a cooling body, we have only to fall back upon its own supply of heat, and to suppose that somewhere not very far below the rocks forming its surface there is a zone of highly heated rock, possibly in a viscous state owing to pressure. As the earth slowly loses heat, contraction of the outer shell follows, and this must involve tangential strains and upheaving along certain lines, because it has to settle down on to a smaller surface. Thus continents are slowly raised, and mountain chains upheaved. These movements cause changes in pressure, and we can readily conceive that a change of pressure may bring about the displacement and wedging up of matter from below, which gets more and more fluid as it ascends

to regions where the pressure is less, until, on reaching the surface, it runs out as lava, and allows its occluded steam freely to escape.

ASTRONOMY AS TAUGHT BY ACADEMY PICTURES.

Mr. Eyre Crowe's picture in this year's Royal Academy Exhibition, representing Jeremiah Horrocks arriving in haste from his clerical duties to find Venus on the Sun, is one of those useful pictures which draw attention to a great man who has not been sufficiently known and appreciated, and I therefore criticize it in no carping spirit. The picture has already caught the public taste, and reproductions of it have appeared in several illustrated papers. I am no advocate of too close astronomical criticism of a picture which is not intended to teach Astronomy, but in this case Mr. Eyre Crowe evidently does intend to present an object lesson in astronomy, and he should either have devoted more time to Horrocks' own account of his observation, or he should have called at the Astronomical Society and applied to the obliging Librarian for advice as to whom to look to for help.

Mr. Eyre Crowe has drawn Venus far too small, and the beam of light should not fill the eyepiece of the telescope. There is no authority for the curious Equatorial mounting which he has drawn, or for the attachment of the sun-screen to the instrument by a rod; in fact, we know that such a mounting could not have been used. Horrocks had been examining the Sun all day, and through his narrow windows he could not have followed the Sun with such an instrument for more than half an hour at most. He would continually have been obliged to move and readjust the position of the Polar axis of his stand, a loss of time and opportunity which the ingenious Horrocks would never have risked. It is evident that the telescope was attached to the shutter, or was on a stand immediately behind a hole in the shutter. In the *Venus in Sole Visa*, in which Horrocks gives an account of his observation, he says: "When the time of observation approached, I retired to my apartment, and having closed the windows against the light, I directed my telescope—previously adjusted to a focus—through the aperture towards the Sun, and received his rays at right angles upon the paper already mentioned."

This paper had upon it a six inch circle, carefully divided into degrees, and a divided scale, which enabled him to measure the diameter of the body of Venus, and the distance of the planet from the Sun's limb. Horrocks goes on:

"The Sun's image exactly filled the circle, and I watched carefully and unceasingly for any dark body which might enter on the disc of light. . . . Anxiously intent, therefore, on the undertaking, through the greater part of the 23rd, and the whole of the 24th, I omitted no available opportunity of observing her ingress. I watched carefully on the 24th from sunrise to nine o'clock, and from a little before ten until noon, and at one in the afternoon, being called away in the intervals by business of the highest importance, which, for these ornamental pursuits, I could not with propriety neglect."

The place of Venus upon the Sun's disc is not quite low enough on the right-hand limb in Mr. Crowe's picture. Horrocks says that it was about "62° 30'," certainly between 60° and 65° from the top of the Sun's disc towards the right. The black disc representing Venus should be larger; Horrocks estimated it to be about a quarter of an inch in diameter or a little more, for he thought that Venus was more than 1′ 12″ and less than 1′ 30′ in diameter. The size of the telescope drawn by Mr. Crowe seems to be about right. The tube was evidently home-made. Horrocks says that he gave 2s. 6d. for the object glass. It is evident from the description of his observation, that Horrocks used what was then known as the Galilean form of telescope, that is, it had a negative and not a positive eyepiece, so that Mr. Crowe is right in drawing the emergent rays of light as not crossing after they issued from the eyepiece; but they should issue in a narrower cone; about a third of an inch in diameter near to the eyepiece. One cannot speak more accurately without knowing the negative focus of the lens used for an eyepiece.

Mr. Crowe should, I think, have drawn Horrocks in a full cassock, as he is returning from service; at this date the clergy wore them at all times. The face seems to me to be rather old for a man who could not have been more than 22. As to the age of Horrocks, see a paper in the *Astronomical Register* for December, 1874.

It is evident that Horrocks could not have entered the room and found the Sun upon his screen and Venus on its disc, for he had no clockwork to drive his telescope. He must have entered the darkened room, found the Sun, and carried his screen to the distance where the Sun's image would fill his divided circle. The picture would be more accurate as depicting Horrocks' friend Crabtree than Horrocks himself. For Crabtree did not measure the diameter of Venus and its place upon the Sun's disc, a task to which Horrocks, in spite of his excitement, set himself at once, and succeeded admirably. All interested in spreading an interest in Astronomy must, however, be thankful to Mr. Crowe, and I hope that he will have many imitators who will dare to run the gauntlet of criticism.

A. C. Ranyard.

THE TRAVELS AND LIFE-HISTORY OF A FUNGUS.

By J. Pentland Smith, M.A., B.Sc., &c., Lecturer on Botany, Horticultural College, Swanley.

Were one to put the question "What is a fungus?" to a non-botanical observer, he would probably receive for an answer "A mushroom is a fungus," getting an example of the group instead of a definition.

A mushroom is a fungus, and a readily observed member of the group; but the botanical tyro quickly learns that this plant cannot afford him a typical example of the life-history of fungi, and that all do not make themselves so evident to the sight as this particular fungus; in fact, he would soon perceive that the air is loaded with the spores or reproductive cells of fungi which are ready to germinate whenever they find suitable quarters.

Within late years our knowledge of the lower members of the vegetable kingdom has made enormous strides, and results have been obtained by careful and prolonged study which would astound the botanists of fifty years ago were they now to appear upon the scene. Then it was believed that Fungi and Bacteria were produced by the decay of other living organisms, and that they were a *lusus naturæ*, a freak of Nature. Their sudden appearance on a spot where no previous indication of their presence had been manifested was adduced as an argument in favour of the doctrine of spontaneous generation, or *generatio æquivoca*, that from unorganized matter living beings may arise. In later times Prof. Tyndall was an upholder of this theory; but as the outcome of his numerous and carefully

elaborated experiments he was forced to confess that no such thing as spontaneous generation takes place—at least, that it cannot be proved to do so.

"It is easy to understand how such ideas of spontaneous generation should have been prevalent in ancient times. Even their repeated occurrence in modern times, and with our modern knowledge, is also capable of explanation. It must be assumed that organisms did once come into being of themselves without parents, being produced from organizable, but yet not organized, matter. It must, moreover, be allowed that this may still happen at any moment, and perhaps does actually happen; its impossibility cannot be proved. To produce actual proof of an original formation of a living being is a matter of the highest interest, and has as powerful an attraction for the biological investigator as the prospect of producing the homunculus in the phial for the alchemist. But the experience of centuries has shown that wherever the homunculus really appeared in the flask it proved itself to be a small imp which had been secretly introduced into it from without; and, speaking seriously, the result was always of this kind. In every single instance exact investigation has shown that the organisms which were supposed to have had no parents proceeded from germs produced from parents of the same species as themselves; it has also been shown how they were formed and whence they came. . . . That there is no generation without parents is a matter of experience; it is in distinct accord with the present state of our knowledge after making allowance for all conceivable possibilities . . ."

What, then, are the organisms which have given rise to such curious notions regarding their mode of origin? We have instanced the mushroom as an example; and to it the toadstools and moulds may be added.

The vegetable kingdom is generally divided into five main divisions, of which the lowest is the Thallophytes (θαλλος "a young shoot," and φυτον "a plant"). The plants of this class show no differentiation into root, stem, and leaf, as is the case in the majority of green plants, but instead are composed of a *thallus*, or body in which no distinction can be made between stem and leaf, and in which a root, such as we are accustomed to in the higher plants, is absent. In this division the Fungi find their place.

It would be impossible in the limits of a single paper to attempt a general description of even the chief members of the various divisions of this enormous group. It will best serve our purpose to confine ourselves to a detailed account of the life of an individual member of one of these. The physiology of the Fungi will, we trust, form the subject of a subsequent paper. Here it will merely receive a passing glance.

We select for our description a Fungus which causes *rust*, or mildew, on grass. Its life-history is extremely complicated, and is intensely interesting. It is a typical *lusus naturæ* of the old authors. The different stages in its interesting life may be traced (now that they are known to us) with comparative ease owing to the large size of its members, so that the readers of this article can thus obtain a first-hand knowledge of some at least of its life processes.

This fungus is the possessor of three names—*Uredo linearis*, *Puccinia graminis*, and *Æcidium berberidis*; the reason of which will be evident to the reader by-and-by. *Puccinia graminis* is the one in common use.

The most conspicuous portion of the fungus, and this holds good for almost all these plants, is that portion set apart for the reproduction of the species. The mushroom is a case in point. The vegetative portion—that part, in other words, which is the carrier-in and elaborator of nourishment—is quite inconspicuous. We will deal with it first. It is the fungus body, the thallus or *mycelium* (μυκης "a mushroom"), and corresponds to the "spawn" of the mushroom. It consists of a number of elongated, many-celled threads or hyphæ (ὑφη "a web"), which branch and interlock to form a more or less compacted weft of tissue. *Puccinia graminis* is a parasite, so we must look for this mycelium in the tissues of a living being, or *host*, as it is termed in technical language.

There are five or more unwilling hosts favoured with this unwelcome guest. We will select one of these—*Triticum vulgare*, the Wheat—for our study of the parasite. It occasionally happens during the early summer that a farmer espies a peculiar colouration on the blades in some parts of his wheat-field. He calls this *mildew*. Closer examination reveals the fact that the blades have a rusty appearance, the *rust* taking the form of small linear patches on the leaves. A microscopic examination of a transverse section of a leaf through one of these patches shows that its tissue is permeated by a number of delicate threads (Fig. I. *b.*, *m.*), which run amongst the cells. At one portion the filaments have assumed an upward direction, and there a mass of yellowish cells have made their appearance (Fig. I. *b.*, *ur. g.*). They are so numerous that the epidermis or skin of the leaf has been ruptured. Each one occupies the end of one of the threads. These threads are the hyphæ of the fungus mycelium. They form the thallus, which corresponds to the root, stem, and leaves of a higher plant, such as its host-plant, the Wheat. Many of the wheat-cells are stored with green colouring-matter, or chlorophyll, which enables it to lead an independent existence,* but in the thallus of the Puccinia there is no green colouring-matter; hence it must live on matter which has already been elaborated from inorganic materials by its more favoured host. So far as regards structure, a difference exists between the two, occasioned, of course, by the very different mode of life of the two forms. In the Wheat-plant certain cells are set apart for the performance of certain functions. Each *set* of cells is called a tissue. No such distinction can be drawn between the cells of the fungus mycelium; they are all alike. Each one can take in nourishment for itself from the cells of the leaf in which it has found a home.

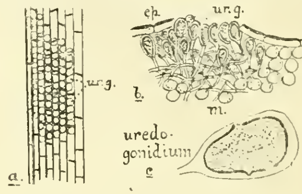


Fig. I.—*a.* Diagrammatic representation of surface of leaf of Wheat (*Triticum vulgare*) slightly magnified. The uredo-gonidia (*ur. g.*) are seen shining through. *b.* Transverse section of leaf of Wheat through a uredo-gonidia patch. *Ur. g.*, uredo-gonidia; *ep.*, epidermis; *m.*, mycelium, the threads (*hyphæ*) of which are woven into a loose tissue. (Much magnified.) *c.* Uredo-gonidium. (Very much magnified.)

Of the yellow cells we have not spoken. They are called gonidia or conidia-gonidia (γεννάω "to produce," and οἰδα "like"), because they are like spores; true reproductive cells; and conidia (κονις "dust"), from their dust-like appearance. They are not spores, inasmuch as they have

* For explanation, see article on "Breathing Organs of Plants," Knowledge, Nov. 1890.

not been produced as the result of the union of male and female elements. They have simply been cut off, one by one, from the ends of the hyphæ, and have surrounded themselves with a thick wall as a protective covering; but, like spores, they are capable of germinating and producing a mycelium exactly similar to that which gave them origin. The wind catches them and carries them from blade to blade of the wheat. Having alighted thereon, germination commences. A small tube is sent out from each gonidium; it pierces the cuticle or outer coating of the leaf-surface, and insinuates itself between the cells of that body. It probably effects its entrance into the leaf by secreting a ferment which dissolves the hard cuticle. This fermentation is exhibited by many fungi. It enables many of them to penetrate into the hard wood of trees. When the tube has reached the interior of the leaf, it germinates, and the product of germination is a mycelium like that of its parent. On this gonidia may again arise. Two or three generations of gonidia may be produced in this way in a single summer.

The fungus at this stage was formerly called *Uredo linearis*, and its gonidia are still known as *Uredo-gonidia*.

The blade of wheat is a transitory structure, it does not live all winter, but the mycelium of the fungus could not survive that period without a means of sustenance. In point of fact, its existence as such terminates with that of the life of its host; but it makes provision for the continuance of the species, to the cost of the poor farmer on whose lands it has settled.

Towards the end of July the brownish pustules we have previously referred to assume a black appearance, and become more prominent. Now, microscopic examination reveals a curious fact. Where previously uredo-gonidia existed, two-celled bodies with very thick walls have appeared (Fig. II. *a.*, *t.g.*). On some isolated stalks a uredo-

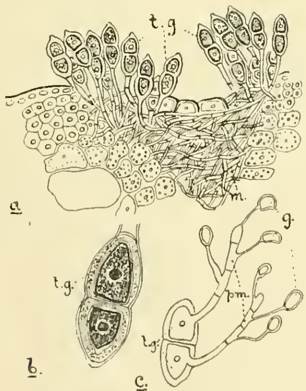


Fig. II.—*a.* Transverse section of Wheat-blade through collection of Teleuto-gonidia (*ad. nat.*); *t.g.*, teleuto-gonidia; *m.*, mycelium. (Much magnified.) *b.* Teleuto-gonidium (*ad. nat.*) (Very much magnified.) *c.* Diagrammatic representation of germination of teleuto-gonidium (*t. g.*); *p. m.*, promycelium; *g.*, promycelial gonidia.

gonidium may still be visible. These are also gonidia, but by reason of their structure are better fitted to withstand the rigors of winter than those produced in the earlier part of the season. They are the last gonidia to appear on the mycelium, so they have received the name of teleuto-gonidia (τελευτος "last").

All this time the fungus has been preying upon its host, and preventing the elaboration of sap for the building up of its seeds. Its attacks are thus dreaded by the farmer. This stage of the fungus, which was not known until recently to have any connection with the preceding, received the name of *Puccinia graminis*.

The mildew, or blight, was known as far back as the time of Shakespeare. In *King Lear*, Act III. sc. iv., we read that "the foul fiend Flibbertigibbet mildews the white wheat." "The fungoid nature of the mildew was not known, however, until the latter half of the last century, for Tull, writing in 1733, attributes it to the attack of small insects, 'brought (some think) by the east wind,' which feed upon the wheat, leaving their excreta as black spots upon the straw, 'as is shown by the microscope.'!"*

The teleuto-gonidia remain on the decayed leaves all winter, but in the spring they throw off their dormant state, become active, and germinate. Each division sends out a small tubular body (Fig. II. *c.*, *p.m.*) which divides up into three or four cells that still retain organic connection with one another. From each cell is thrown out a short process, whose tip develops into a minute bulbous swelling (Fig. II. *c.*, *g.*). The two tubes produced from the teleuto-gonidia are called promycelia, and the swellings just mentioned the promycelial gonidia. These last are produced in immense numbers, and are carried about by the wind.

It was noticed many years ago that in the vicinity of Barberry bushes (*Berberis vulgaris*) the wheat in a wheat-field presented the *rusted* appearance which we now know to be due to the presence of teleuto-gonidia, while in neighbouring parts the wheat retained its normal appearance. Many accounts were given of the connection between the Barberry and mildew on wheat, but no one knew why this connection should exist. So convinced were farmers of the harmful nature of the Barberry that almost all these bushes have been uprooted from our hedges; and in 1760 an Act was passed in Massachusetts enforcing the destruction of these apparently harmless shrubs.

The promycelial gonidia, one would naturally imagine, would germinate on the wheat-leaves, but experience tells us that this does not take place. They will only develop when they fall on the Barberry, or its ally the *Mahonia ilicifolia*. In the leaves of the former plant, and in addition on the berries of the latter, they develop a mycelium in no way differing from that seen in the leaves of the wheat. The hyphæ or threads of the thallus insinuate themselves between the cells, and absorb nourishment from them. Its presence on the Barberry would probably have passed unnoticed were it not that during the early summer reproductive cells arise from the mycelium. Then it is seen that the under surface of the leaves are infected here and there with circular yellow blotches. The aid of a pocket-magnifier shows each blotch to be composed of a zone of small holes, from which a yellow powder issues. On the upper side of the leaves minute apertures are present, arranged likewise in a circular manner. If we examine a section of the leaf under the microscope, the yellow patches will show themselves to be composed of cup-shaped bodies. Every cup is filled with bright yellow cells (Fig. III., *a. sp.*) arranged in linear series, and each series arises from the down-turned end of a hypha. A distinct wall surrounds each cup or *æcidium* (Fig. III., *a.*),

* Plowright. *British Uredineæ and Ustilagineæ*, p. 47.

and, like the spores, it is connected with a mycelium in the centre of the leaf. The arrangement of the æcidia in groups has caused them to be called cluster-cups. The mycelium is connected towards the upper surface of the leaf with oval-shaped bodies, spermagonia (Fig. III. *s.*), whose openings to the exterior are the small apertures before-mentioned. They contain rod-shaped cells, the so-called spermatia (Fig. III., *sp.*).

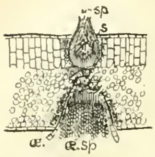


FIG. III.—Transverse section of leaf of Barberry (*Berberis vulgaris*), showing æcidium (*æ.*), with æcidiospores (*æ. sp.*), and spermagonium (*s.*), with spermatia (*sp.*).

As in the previous stages, this phase of the life-history of the fungus was not known to have connection with any of the others, and had a name of its own—*Æcidium berberidis.*

It now remains to determine the origin and use of these respective parts. The Aphis, or plant-louse, has the peculiar power, possessed, however, by other lowly animals, of producing numerous successive broods of young from unfertilized eggs. This is called parthenogenesis (παρθενος "a virgin"; and γεννάω "to reproduce"). On the prothallus* of the Fern antheridia and archegonia may be developed, but from the ovum, or egg, in one of the latter a young fern-plant may arise without union with a spermatozoid; nay, further, without even the production of an ovum a fern-plant may be developed on it. As it is usual for fertilization to take place, these abnormal developments are termed *apogamous* (ἀπο "from"; and γαμέω "to marry"). In a group of Fungi allied to that (*Æcidiomycetes*) to which Puccinia belongs, viz. in the Lichens, spermatia are developed. One fertilizes a female organ, *and the result of their union is a cup-shaped body very much like the æcidium of Æcidium berberidis.* No female organ has been found on this fungus, so it is argued that apogamy here takes place. As the yellow cells germinate and produce a mycelium, and as they have resulted from the union of male and female elements, they are called spores, in contradistinction to the asexually-produced reproductive cells, gonidia. It was believed until lately that the so-called spermatia were male cells, which were now functionless on account of apogamy always happening in *Æcidium berberidis*; but this view of their nature must now be cast aside, for Prof. Plowright has succeeded in causing these to germinate. Their true nature at the present time is unknown.

The inability of the promycelial gonidia to germinate on the blades of Wheat is a matter of wonderment, but the same peculiarity is displayed by the spores (*æcidiospores*) found in the æcidia, or cups of the Berberis. They will germinate only when they reach a blade of Wheat, and not on the Berberis leaf from which their parent mycelium derived its sustenance. Their germination presents features akin to that of the uredo-gonidia and teleuto-gonidia. A tube is sent out, which in this case, however, enters the wheat-blade by way of a stoma. In the interior of the leaf it branches and produces a mycelium, on which uredo-gonidia are produced.

We have thus arrived at the stage of the life-history with which our description commenced. This fungus then passes part of its existence on one plant and part on another, and is parasitic on both. It is thus said to be metoxenous (μετα "change"; and ξενος a "guest"); or, in other words, to change its host. The term heterœcism (ἑτερος "other," and οἰκος "a house") is also used in connection with it, implying that it effects a change of residence during the course of its life. The diagram (Fig. IV.) will

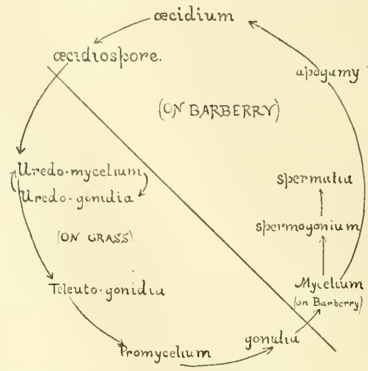


FIG. IV.—Life-cycle diagram of *Puccinia graminis.* As the uredo-mycelium produce uredo-gonidia, which again produce a mycelium like the parent, the life-cycle is at this stage lengthened, while on the other side apogamy causes shortening of the cycle.

serve to make clear the wanderings and vicissitudes of this lowly organism.

It must not be imagined that all Fungi have such a complicated life-history. In many cases it is very simple. Moreover, all are not parasitic; some are saprophytes. They live, like the mushroom, on dead organic matter, which originally was built up by living beings.

* For explanation of terms see article on "A Seed, and what it Contains," KNOWLEDGE, April 1891.

Notices of Books.

Soap Bubbles and the Forces which mould them. By Prof. C. V. Boys, F.R.S. (Society for Promoting Christian Knowledge.)—This very fascinating little book is calculated to start old people as well as young in a course of experimenting for themselves. It is written in very popular language, being the substance of three lectures delivered to a juvenile audience in the Theatre of the London Institution. Prof. Boys is a very accomplished experimenter, with a happy gift of devising simple mechanical contrivances to illustrate his meaning. Those who were not fortunate enough to hear the lectures will find ample wood-cuts and other illustrations to make the meaning clear, and at the end of the book Prof. Boys has given a series of practical hints as to bubble-blowing and making some of the simple apparatus which he used. The importance can hardly be overrated of inducing young people to experiment for themselves. It teaches them to observe and to reason for themselves, and is a very important adjunct to the training of the memory which is now too exclusively looked upon as education. Possibly in some cases Prof. Boys has been a little too daring in his attempts at explanation. Thus, in trying to explain that the section of a film between two parallel discs is a catenary when the pressure on the inside is equal to the pressure on the outside, he shows his child audience the sections of a cone by throwing the shadow of a flat candlestick on the wall, and then tells them that he will trace a catenary by rolling upon a straight edge a piece of board, cut into the form of a parabola, letting a piece of chalk, at its focus, trace the catenary on the black-board. But with a

few such small exceptions, the book is exceedingly simple as well as amusing.

The Autobiography of the Earth: A popular account of Geological History. By the Rev. H. N. Hutchinson, B.A., F.G.S. (Edward Stanford, London, 1890). There is a scarcity of popular works on Geology which can be relied upon as giving accurate information in simple language. This book has been very conscientiously written. It gives a brief sketch of the principal geological periods, and endeavours to explain briefly the methods by which the conclusions of geologists have been arrived at.

Monograph of the British Cicadæ. Part V. By G. B. Buckton, F.R.S. (Macmillan & Co.) This part contains the *Acocephalidæ* and the first two genera of the *Jassidæ.* There is also a useful chapter on the parasites of the Cicadæ, for which no hint of apology was necessary, for in our opinion it is just the discussion of side issues such as these that, next to the figuring of the species, constitutes the chief *raison d'être* of the work. The parasites of the Homoptera have been so little studied in this country that all available information will be welcomed by students of the order. The most interesting subject noticed in this connection is the investigations of Prof. Mik and others into the nature of the black oval objects which so often disfigure the bodies of the *Jassidæ* and *Typhlocybidæ.* These have been proved to yield hymenopterous parasites belonging to the extraordinary ant-like genus *Gonatopus*, but many points in the life-history of the parasites still need elucidation, and it is to be hoped that Mr. Buckton's summary of results may lead others to take up the subject. The coloured plates are not all of equal merit, and the figures of one insect at least, the handsome and brilliant *Platymetopius*, suffer from the unusual defect of being insufficiently coloured.

Nature's Wonder-Workers. By Kate R. Lovell. (Cassell & Co.) Another book on the inexhaustible theme of insect life and habits. Though the authoress does not profess to write in other than a somewhat popular style, her work is carefully done, and shows an avoidance of those blemishes of style that too often disfigure works of this sort. Into 280 agreeably written and neatly printed pages has been collected a considerable fund of information, for the most part accurate, about some of the familiar insects that more or less directly affect the welfare of mankind. The book is most attractively got up and illustrated with abundance of woodcuts, which are full of life and vigour, and portray many and varied phases of insect life.

By Track and Trail: a Journey through Canada. By Edward Roper, F.R.G.S. (W. H. Allen & Co., 1891.) The author of this chattily written book makes no pretensions to be a naturalist or scientific traveller, but he is an artist with an eye for birds and beasts, as well as for the grand scenery of the north-west. He introduces his readers in a realistic way to a wide range of country extending from the Atlantic to the Pacific, and to many types and conditions of men, taking us through the great wheat-growing country to prairie ranches and the cañons and passes of the Rocky Mountains on to British Columbia. His picture of a Chinook village on Queen Charlotte's Island, named Skidegate, shows the gigantic carved posts which these Indians erect in front of their houses. Speaking of these totem posts Mr. Roper says, "I had always been under the impression that the totem was held sacred by the tribe or family possessing it, and that they would not injure or allow to be injured the object chosen as the symbol of their tribe; but at Skidegate their totem is the shark, yet this family of Indians are famous shark slayers, killing them for profit." The houses of these Indians are most substantial wooden framed structures, sometimes forty feet long and equally deep—the walls and the roof are made of split slabs of cedar. It is surprising what immense beams and posts they use for these houses. When an Indian wishes to build a house he gets up a "bee." Calling the members of his tribe together he distributes presents amongst them, which are called "potlach." They set to work with a will, drawing and fitting together great logs until the house is completed. One of the most striking features of these Indian villages are their totem posts, which are sometimes three or four feet in diameter and forty feet high. They are carved with great grotesque faces and figures and a representation of the animal representing the clan. Mr. Roper likens the posts to a family coat-of-arms, which also records incidents in the family history.

THE COAL-SACK REGION OF THE MILKY WAY.

By A. C. Ranyard.

Near to the foot of the Southern Cross there is a dark patch or hole in the Milky Way which was named by the early English-speaking navigators of the Southern Seas "The Coal-Sack," on account of its blackness as compared with the surrounding region. It is so striking an object in the Southern skies that even the Australian natives seem to have noticed it. It is stated, on the authority of a paper read before the Royal Society of New South Wales,* that this black patch figures in Australian folk-lore as the embodiment of evil in the shape of an emu who is lying in wait for an opossum that has climbed into the branches of a tree represented by the stars of the Southern Cross.

The physical meaning of this dark area in the midst of a closely star-strewn region has long been a subject of speculation. It has generally been described as some 8° or 10° long by 5° or 6° wide, with sharply-defined borders, and as perfectly devoid of stars. Proctor rejected as highly improbable the idea that there could be a tunnel directed towards the earth through a great thickness of stars, and accounted on his stream theory of the Milky Way for the dark patch as an opening where we look into distant space between two branches of the great galactic stream of stars, which he conceived to be a stream of roughly circular section. In an article on the Coal-Sack Region, published in Knowledge for May 1st, 1886, p. 225, he asks the reader to consider whether it can be "an accident that over this large dark space, covering about 50 square degrees, there is not a single lucid star, while all around its borders lucid stars are strewn in plenty?" The whole surface of the heavens, he remarks, "exceeds the Coal-Sack some eight hundred times in extent; and as there are about 6000 lucid stars, one might expect seven or eight such stars to be found in the Coal-Sack. But this is far from being all. The neighbourhood of the Coal-Sack is much richer in lucid stars than other regions in the heavens; so that it is just where stars should be most richly distributed that this vast black spot makes its appearance." The question whether the absence of naked eye stars from the Coal-Sack Region and their presence in great abundance in the Milky Way Region around can be a mere coincidence can hardly be regarded as doubtful, and every thoughtful person will acknowledge that the observed distribution tends to show an intimate connection between the naked eye stars and the distribution of the smaller stars or nebulous matter, which gives rise to the hazy stream of light we know as the Milky Way.

* See Miss Clerke's *System of the Stars*, p. 356.

The photograph of α and β *Crucis* and the Coal-Sack Region which we are enabled, by the kindness of Mr. H. C. Russell, Director of the Sydney Observatory, to lay before the readers of KNOWLEDGE, shows that the Coal-Sack is far from being absolutely void of stars; the greater part of it is bridged over by a network or veil of stars which are relatively minute compared with the larger stars that are scattered over the region surrounding the Coal-Sack. This network of minute stars does not cover the whole of the Coal-Sack area. There are small regions, one notably towards the northern end of the Coal-Sack and one near to α *Crucis*, which show a comparatively black and starless background. It is evident that the structure of this portion of the Milky Way cannot be accounted for by the simple cylindrical streams imagined by Mr. Proctor.

The relative blackness of the Coal-Sack Region, as seen by the naked eye, seems to be due to a breach in a network or structure of larger stars, which are evidently distributed in a different manner to the network or structure of small stars which stretches across the Coal-Sack Region. The two systems or groupings of stars need not necessarily lie at greatly different distances, but they seem to be as independent of one another as the distribution of two flocks of birds. There may be some general law connecting the association of two flocks or flights of birds, and yet each may have its own independent arrangement, as for example, one set of larger birds might be attacking or following a flight of smaller birds or insects. We should then expect to find the two flights intermixed as seen on the sky and yet distinctly separate both by their grouping as well as by their size. Thus we find in the photograph stream lines of minute stars as well as stream lines of stars of larger magnitude.

In this region of the Milky Way, stars of similar magnitude seem generally to be associated together in the stream lines. There is a very remarkable series of such diverging stream lines about the bright star α *Crucis* (the lowest of the bright stars on the plate). A circle of small stars may be traced around the large star, within the sharply defined bright ring, which, as was explained in KNOWLEDGE for July of last year, p. 174, is due to the reflection of the light of the bright star from the back of the plate.* Converging towards this circle of minute stars are several curving streams of minute stars, which it seems hardly possible to doubt are associated together. The symmetry of their arrangement with respect to the large star is also very curious. From a probability point of view, it is overpoweringly evident that these diverging streams of small stars, together with the circular stream of small stars from which they spring, form a cluster and are all at about the same distance from us. The fact that α *Crucis* falls apparently at the centre of this curiously symmetrical cluster may be a mere coincidence, and may not indicate any physical connection between the cluster and the large star, but the improbability of such a chance coincidence in position is considerable. The evidence, whatever it is worth, is another link in the chain of evidence tending to prove that the girdle of large stars referred to in my paper in the last number is intimately associated with the Milky Way, and that α *Crucis* and the other stars of the girdle are giant suns compared with the cloud of smaller suns which compose the Milky Way. α *Crucis* is a double star with components 5″ apart which move about one another very slowly, for their position seems hardly to have changed since Sir John Herschel observed them in 1834. They give a spectrum of *Sirian* Type. The stars of the cluster about α *Crucis* seem to belong to the class of smaller stars which stretch across the Coal-Sack; one of the branches of the cluster seems to merge into a curiously curving stream of small stars, which stretches a long way if not right across the Coal-Sack area. There is also, on a glass positive sent me by Mr. Russell, a narrow black channel, bordered by small stars, which stretches right across the Coal-Sack area.

The other photograph reproduced represents the Milky Way, about η Argus, a region which Sir John Herschel thought was composed of stars of larger average magnitudes than other parts of the Milky Way (see *The Cape Observations*, p. 33). He also thought that it differed from other regions of the Milky Way, in that the stars appeared distinctly separated on a perfectly dark background. It is seen here to be composed of a series of clusters separated by a number of darker patches and lanes. It seems clear that the Milky Way is by no means homogeneous; different parts exhibit great differences of star grouping—just as one region of the Milky Way is rich in red stars, while another is rich in stars having bright line spectra, so one region seems to be composed of large stars, and another of relatively small stars, and the method of their grouping in different regions is also strikingly different. This was long ago noticed by Sir John Herschel. He says,† speaking of the region at 17h. 50m.: "The Milky Way is here composed of separate, or slightly or strongly connected clouds of semi-nebulous light, and as the telescope moves, the appearance is that of clouds passing in a *scud*, as the sailors call it . . . . The Milky Way is like sand, not strewed evenly as with a sieve, but as if flung down by handfuls (and both hands at once) leaving dark intervals." The nebula about η *Argus*, though comparatively brilliant in the telescope, seems to be deficient in actinic or photographic light, and consequently to need very long exposures as compared with the great nebula in *Orion*. Mr. Russell says that he can trace on his original negative curving structures, which he says remind him of the great nebula in *Andromeda*. Only three stars are shown in the great dark oval patch in this nebula where Herschel's drawings give four. The dark region, known as the Lemniscate, also appears quite void of light and of stars, except the one small star observed by Herschel, but the scale of the photograph is too small to show much detail. The scale of both photographs is 1° = 0·566 inch. They were taken with a Dallmeyer six-inch portrait lens attached to the mounting of the telescope, which will be used for taking part in the photographic survey of the heavens.

* During the exposure of the photographic plate, a point on the sensitive film was lit up by the image of the bright star, and shone like a little lamp. The rays from this illuminated region, which fell nearly perpendicularly on the back of the plate emerged, whereas those which fell more obliquely would be in greater and greater proportion reflected back again, and produce their effect on the sensitive film. The inner edge of the bright ring corresponds to the light reflected at the critical angle where the whole of the light is reflected back again to the sensitive film, and none gets out at the back of the plate.

† *Cape Observations*, p. 388.

FLYING ANIMALS.

By R. LYDEKKER, B.A.Cantab.

ONLY in certain members of two great groups of animals do we meet with the faculty of flight, or the power of supporting their bodies in the air for longer or shorter periods by the aid of membranous or other expansions developed therefrom. These two groups are the Insects, which constitute a class of the larger group known as the Arthropodous sub-

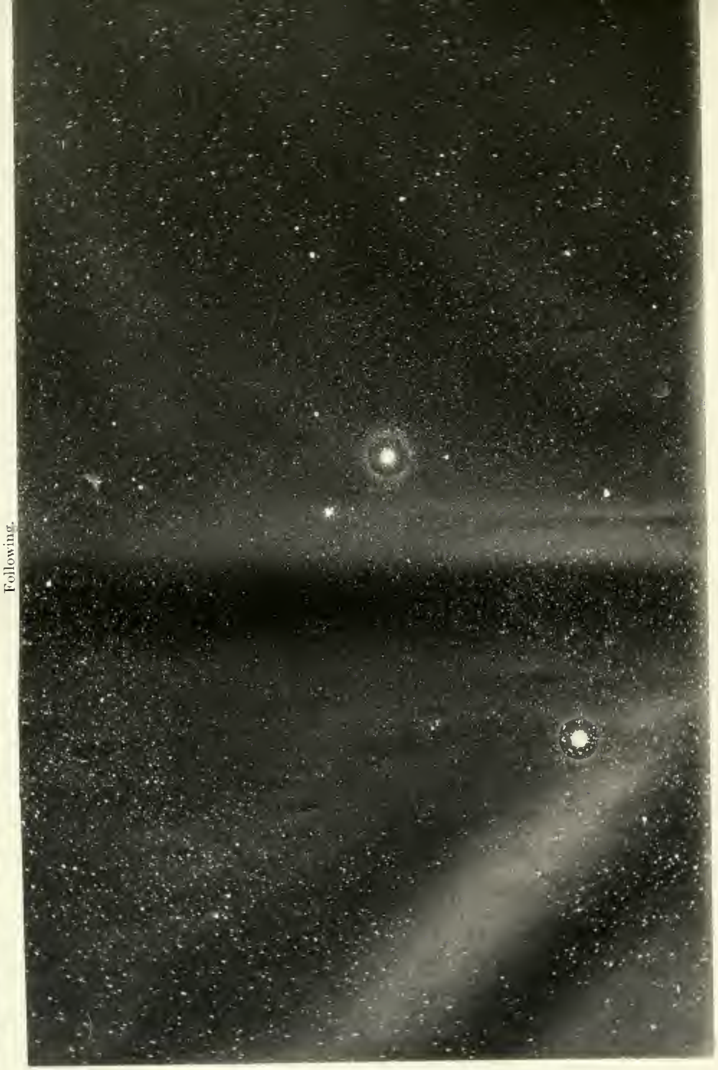
North.

The η Argus Region and Neighbouring Clusters in the Southern Milky Way.

From a Photograph taken by Mr. H. C. Russell, Director of the Sydney Observatory. Exposure, 3 hours. 23rd July, 1890.

South.

Following.



α and β Crucis and the Coal-Sack Region of the Milky Way.

From a Photograph by Mr. H. C. Russell. Exposure, 3 hours. 13th August, 1890.

Preceding.

Direct Photo Eng. Co., Limited, 9, Barnsbury Park, N.

kingdom, in which are also included spiders and crabs; and the Vertebrates, which form a sub-kingdom to themselves. Whereas, however, by far the great majority of Insects are endued with this faculty, among the Vertebrates it is only in the class of Birds that we meet with a similar preponderance of species which enjoy this kind of locomotion, although all the members of certain orders—the Pterodactyles and Bats—are similarly endowed. Moreover, we have to draw a distinction between true flight, as exemplified by Birds, Bats, and Insects, and what we may call spurious flight, of which we have examples in Flying Phalangers, Flying Squirrels, and Flying Fish. True flight is performed by an alternate upward and downward motion of the wings, or special organs of flight, and can be indefinitely prolonged until the muscular powers of the flyer are exhausted. On the other hand, spurious flight is merely a prolongation of a downward or upward leap by means of parachute-like expansions developed on the sides of the body, or, as in the Flying Fish, by passive extension of wing-like organs, and it can never be extended beyond the limits of the initial velocity of the original leap. This distinction between true and spurious flight is a very important one, since it shows us that the animals endowed with the former power are limited to four groups, namely, Insects, the extinct Pterodactyles or Flying Dragons, Birds, and Bats. Spurious flight, on the other hand, is found in Flying Fish, Flying Lizards, Flying Phalangers, Flying Squirrels, and Flying Lemurs. Among those animals capable of true flight a broad line of distinction separates the Insects from the Vertebrates in regard to the organs set apart for this particular purpose. Thus, whereas in Insects, all of which are provided with six pairs of legs, the wings, or special organs of flight, are frequently four in number, and are in all cases developed from the back of the body, entirely independent of the legs; in Vertebrates, where the number of legs never exceeds four, the two wings are always formed by special modification of the first pair of legs. It is therefore evident that although the wings of Insects, as performing similar functions, are analogous with those of Vertebrates, yet, as being structurally quite different, they are in no sense homologous with the same.

The special modification of the first pair of legs to subserve the purpose of flight in those Vertebrates which possess this power in its true form, may be taken as an indication that such Vertebrates have originally descended from others in which that power was not developed. Although we have no such guide in the case of Insects, yet the circumstance that in all those kinds which undergo a complete metamorphosis no traces of wings are observable in their larvæ, points with equal clearness to the conclusion that these creatures have been likewise derived from crawling ancestors, and that their power of flight is an acquired one. Those Insects which are unable to fly must not, however, be regarded as ancestral forms, since there is clear evidence that their wings have been lost or have became rudimentary. It has been already mentioned that while all flying Vertebrates have only a single pair of wings, many Insects are provided with two pairs of these organs; and from the tendency among Insects for one or other of these pairs of wings either to disappear or to be modified for other purposes, it would appear that a single pair is decidedly the best suited for flight.

We shall now proceed to trace some of the chief modifications in the organs of flight in the different groups of animals, commencing with Insects, in which, as already observed, we never meet with spurious flight.

In all the Beetles, or Coleoptera, which form the first order of Insects, the front pair of wings are modified into the well-known horn-like wing-covers, or *elytra*, beneath which the membranous second pair are neatly folded during such times as the creatures are not engaged in flight. In some kinds, such as the Stag-Beetle and the Water-Beetles, these wing-cases are long, and extend backwards to the hinder extremity of the body; but in others, like the well-known "Devil's Coach-Horse," they are extremely short. The modification of the front wings into wing-covers clearly indicates that Beetles are a highly specialised group; the extreme development of this specialisation occurring in certain species like the Oil Beetle, where the second pair of wings have also become rudimentary, so as to render their owner incapable of flight. In some degree a confirmation of this specialisation is afforded by the circumstance that Beetles are not known in the fossil condition so far down in the geological scale as are some of the more generalised groups of insects.

In the Bees, Wasps, Ants, and other members of the second order Hymenoptera, both pairs of wings are membranous and adapted for flight; the front pair being, however, considerably the larger of the two. In the Caddis Flies and other Neuroptera, both pairs of wings are likewise fully developed and membranous in structure, although differing in the mode of arrangement of their veins. Moreover, the hinder pair are frequently nearly as large as the front ones, a circumstance which seems to indicate that the whole group is a more generalised one. The development of the well-known minute scales on both pairs of wings in the Butterflies and Moths readily distinguishes the Lepidoptera from all other insects, and likewise suggests that they form a much specialised modification of the class. Still greater specialisation as regards their organs of flight is, however, presented by the Flies and Gnats, constituting the order Diptera, in which, while the front pair of wings are large and membranous, or hairy, the second pair are reduced to small, drumstick-like processes termed balancers, or *halteres*, which are of no sort of use in flight, and are typical rudimentary organs. The specialisation of the wing-structure in this group is, therefore, exactly the opposite of what occurs among the Beetles, where, as we have already seen, it is the first pair of wings which takes no part in flight. In the Cicadas and Bugs (Fig. 1), constituting the order Rhynchota, the wings, when present, are four in number, but the first pair may be converted into horny wing-covers, as in the Beetles. Like those of the next order, all the members of this group differ from the insects mentioned above in that they do not undergo a complete metamorphosis before attaining their final perfect state. The last order that we have to notice is the Orthoptera, in which are grouped the Grasshoppers, the Cockroaches, the Earwigs, the Dragonflies, &c. Except in a few parasitic and some other

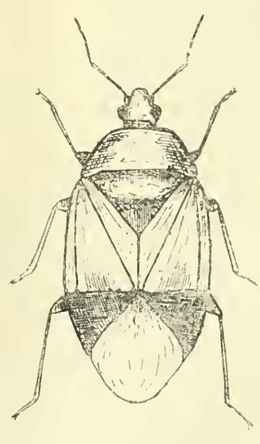


FIG. 1.—ENLARGED VIEW OF A FLYING BUG, WITH THE WINGS CLOSED.

forms, all these insects are furnished with two pairs of wings, which differ, however, greatly in structure. Thus, while in the Dragon-flies, which in this respect may be regarded as the more generalised representatives of the order, both pairs of wings are large and membranous; in the Grasshoppers, Cockroaches, and Earwigs the front pair are leathery, and serve as wing-covers to the hinder pair, which are folded beneath them in a beautiful, fan-like manner. Whereas, however, in the Grasshoppers the first pair of wings still take some small share in flight, in the Earwigs they are extremely small, and serve solely as covers. The Earwigs, therefore, which many people believe to be incapable of flight, represent the extreme of wing-specialisation in this group of Insects.

This closes the list of flying creatures found among the Invertebrates, and we pass, therefore, to the Vertebrates, where we find our first examples of flight among the class of Fishes. In this group, however, in spite of assertions to the contrary, there is no instance of true flight; such fishes as are able to fly at all merely doing so after the spurious manner. The longest flights are made by the

Fig. 2.—The Flying Fish

well-known Flying Fishes (Fig. 2) of most of the warmer seas, in which the first pair of fins are greatly elongated for this purpose. These fishes rise from the water with an upward impulse made by the sides of the body and tail, and they may remain above the surface for a distance of 200 yards. They do not usually reach a height of more than a few feet above the water, although they occasionally spring so high as to alight on the decks of ships. There are few more beautiful sights than to watch from the bows of a large ocean steamer a shoal of Flying Fish as they rise one after another, with their quick meteor-like flight, and then as suddenly disappear beneath the dark waters.

Flying Fish, it may be observed, are first cousins of the common Herring. The only other Fish endued with the power of flight are the Flying Gurnards, which belong to a totally different group, and of which there are three kinds inhabiting the Mediterranean and most tropical seas. All of them are larger and heavier than the true Flying Fishes, although they fly in the same manner.

It has been stated that a Frog from the Malay region uses the large webs on its feet as a kind of parachute in its descent from the trees on which it dwells to the water, but later researches do not lend countenance to this idea; and our next examples of flight must accordingly be drawn from the class of true Reptiles. Among living Reptiles there is no instance of true flight, although two groups are endowed with the power of spurious flight. The first example of this is the Flying Gecko, a small lizard, belonging to that peculiar group so well known in tropical climates from their habit of running up and down the walls of dwelling-houses. The Flying Gecko is an inhabitant of Borneo, Java, &c., and attains a length of about 7 inches. Its sides, limbs, tail, and head are furnished with loose expansions of skin which, becoming inflated with air, act as a parachute in the long, flying leaps which the creature is able to take from tree to tree. The true Flying Lizards, which range from India to the Philippines, have their parachutes constructed after a totally different fashion. In these creatures the last five or six ribs are greatly elongated to support an expansion of the skin of the flanks, which forms a fan-like wing on either side. The late Prof. Moseley described these lizards in the Philippines as flying so rapidly from branch to branch that the extension of their parachutes could scarcely be observed; and also states that some kept on board ship were in the habit of flitting from one leg of the table to another.

Since the extinct Flying Dragons or Pterodactyles of the Mesozoic epoch, which are the only reptiles capable of active flight, have been described at length in a previous article, our allusion to them will here be brief. These extraordinary creatures, as shown in Fig. 3, were fur-

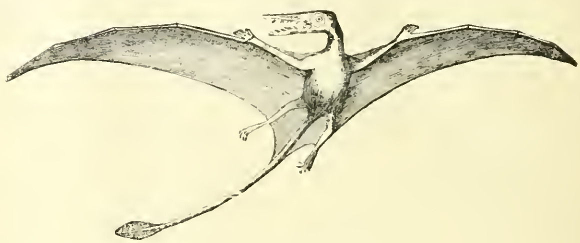


Fig. 3.—Restoration of a Long-Tailed Pterodactyle. ¼th Natural Size. (*After Marsh.*)

nished with thin membranous wings, which were supported in front by the arm and fore-arm near the body, and at their extremities by the greatly extended joints of a finger corresponding either to the ring or little finger of the human hand. The membranous expansion was continued down the sides of the body to embrace the legs and the upper part of the tail; while in at least some of those species in which the tail was long, its extremity was furnished with a racket-shaped expansion of membrane (as in Fig. 2), probably used as a kind of rudder during flight. Some of these creatures were of enormous dimensions, having an expanse of wing estimated at upwards of 25 feet. That they were endowed with the power of true flight is perfectly evident from their general structure; as is especially shown by the strong ridge developed on the breast-bone for the attachment of the muscles necessary for the down-stroke of the wings. Their mode of flight was probably very similar to that of Bats, which they appear to have resembled in their wing-membranes, although the support of these membranes, as we shall subsequently see, was arranged on a totally different plan in the two groups. It is, perhaps, superfluous to add that any resemblances existing between Pterodactyles and Birds are solely due to their adaptation to a similar mode of life, and that there is not the remotest genetic connection between them.

We come now to the Birds, in which true flight has attained the fullest development, and the whole organization is profoundly modified to suit the exigencies of a more or less completely aërial mode of life. It is true, indeed, that certain birds, such as the Ostrich, Cassowary, and Penguins, are totally incapable of flight; but this

incapacity is certainly an acquired one in the last-named bird, and there is a considerable probability that it was likewise so in the two former.

The great peculiarity whereby Birds differ from all other animals is in the presence of their external covering of feathers. A feather, as we all know, is one of the most beautiful objects in nature; and its structure, which we may, perhaps, explain in a later article, is an admirable instance of adaptation for a particular purpose. The uses of feathers are two-fold. In the first place, the small ones with which the body is clothed form the most perfect covering that can be imagined to ensure the maintenance of the high bodily temperature so essential to the active existence of a bird. Then, again, the larger and stronger feathers of the wings are the most efficient instruments for obtaining the utmost advantage from the resistance of the air to their strokes during flight. The peculiar nature of the wings of Birds may be summarised by the statement that whereas all other animals fly by means of expansions of the skin itself, these alone fly by means of separate outgrowths or processes developed from the skin.

(To be continued.)

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

To the Editor of Knowledge.

Mackay, Queensland, March 21st, 1891.

Sir,—Is there any *English* work treating of Astronomical Photography?

In G. L. Chambers' "Handbook of Astronomy," Vol. II., 1890, p. 416, a footnote mentions a German work, Konkoly's, published by Halle, 1887, as the only work on the subject.

People who live in the centres of population can, no doubt, get *vivâ voce* instruction; those in distant parts of the world have to depend upon books, and there seem to be none on this subject.

I am one of those who deeply regretted the cessation of Answers to Correspondents in 1885, and of Gossip in 1888, which alone were worth, to me, twice the money paid for Knowledge. I liked the genially caustic pen of the late lamented R. A. Proctor, and his way of making personal friends of his readers. Your obedient servant,

J. Gwen Davidson.

[We have not at present, as far as I am aware, any book in English on Astronomical Photography. A very charmingly illustrated little French book on the subject was issued in 1887 by Admiral Mouchez,* the Director of the Paris Observatory, but it is devoted to giving an account of what has been done, rather than to answering the questions which I imagine Mr. Davidson would like to ask. The photographic difficulties which the astronomical photographer will encounter are dealt with in a legion of text-books. The astronomical difficulties involved in the accurate mounting of his equatorial, and the accurate driving of his clock, cannot, I think, be dealt with by any copy-book rules. To succeed, the astronomical photographer must be naturally an experimenter, his difficulties must be thought out and conquered as they arise. He will soon find the exposures necessary to obtain the best effects. For the Moon, Jupiter and Saturn, in the principal focus, only a fraction of a second is necessary, depending on the aperture and focal length of the telescope, as well as on the altitude of the object above the horizon and the clearness of the night. Hence, these objects, as well as the Sun, can be photographed without a driving clock. Dr. von Konkoly's† book on Astronomical Photography contains a good many woodcuts of instruments and apparatus, but they are not such diagrams that a reader who did not know what was represented could construct an instrument from. This book is also four years old, and Astronomical Photography has made great progress since that time. I would advise any intending astronomical photographer to thoroughly read some book on geometrical optics, and then to think out his difficulties for himself.—A. C. Ranyard.]

To the Editor of Knowledge.

Dear Sir,—Whilst grateful to you and your reviewer for pointing out the mistake in the last edition of my *Celestial Motions* (I might, perhaps, demur to some of the remarks, but do not propose to do so at present), allow me to call your attention to an error in the same number of Knowledge itself (p. 91), which may puzzle many readers. The passage runs: "He [Michell in *Phil. Trans.* for 1767] concludes that there must be some physical connection between the numerous double and triple stars which had already been discovered by Sir William Herschel . . . ." Michell makes no mention in his paper of Herschel's discoveries, nor could he for a similar reason to that which prevented a distinguished personage from seeing a Spanish fleet. It was not in sight; and Herschel's discoveries had not commenced in 1767, the year after he was appointed organist in Bath.

Yours faithfully,

Blackheath, May 6th, 1891. W. T. Lynn.

[Michell's reference to the double and triple stars discovered by Herschel, is in a paper published in the *Phil. Trans.* for 1781. The fact to which I wish to call attention is that Michell's remarkable papers were written before Herschel's discovery that several close pairs of stars were moving round one another. The boldness of Michell's conclusion that there must be a physical connection between close double stars is rendered more remarkable by the fact that, at the date of his first paper, 1767, less than a hundred of such pairs of stars were known. Michell's words in his first paper are well worthy of being quoted at length. He says, at p. 217 of the *Phil. Trans.* for 1767, after speaking of certain stars which appear double to the naked eye—

"If, besides these examples that are obvious to the naked eye, we extend the same argument to the smaller stars . . . . which appear double, treble, &c., when seen through telescopes, we shall find it still infinitely more conclusive, both in the particular instances and in the general analogy arising from the frequency of them. We may from hence, therefore, with the highest probability, conclude (the odds against the contrary opinion being

* "La Photographie Astronomique a l'Observatoire de Paris." Par M. le Contre-Amiral E. Mouchez. Paris, Gauthier-Villars, 55. Quai des Grands-Augustin, 1887.

† "Praktische Anleitung zur Himmelsphotographie nebst einer kurzgefassten Anleitung zur modernen photographischen Operation und der spectral photographie im cabinet von Nicolaus von Konkoly. Halle, 1887.

many millions to one) that the stars are really collected together in clusters in some places, where they form a kind of system, whilst in others there are either few or none of them, to whatever cause this may be owing, whether to their mutual gravitation, or to some other law or appointment of the Creator; and the natural conclusion from hence is, that it is highly probable in particular, and next to a certainty in general, that such double stars as appear to consist of two or more stars placed very near together do really consist of stars placed near together, and under the influence of some general law."

Herschel subsequently greatly enlarged the list of telescopic double stars which he sought for and measured in the hope of finding some in which the distance and position angle might vary in the course of the year, indicating a parallax as the earth moves round its orbit. But instead of finding a yearly oscillation in the distance and position angle as he expected, he found to his surprise, in many cases, a regular progressive change which indicated that one of the stars was slowly describing a regular orbit round the other. This discovery was announced in Herschel's paper in the *Phil. Trans.* for 1803 and 1804. In speaking of this discovery Herschel said that he "went out like Saul to seek his father's asses, and found a kingdom," the dominion of gravitation extending to the stars. A dominion which, it should be noted, the Rev. John Michell had six-and-thirty years before prophesied would be found to exist, and which in his paper of 1784 he had still more confidently asserted must exist.—A. C. Ranyard.]

STATIONARY RADIATION OF METEORS.

To the Editor of Knowledge.

Sir,—I note some remarks in your current number, bearing on the Stationary Radiation of Meteors. The difficulty of reconciling this feature with theory is well known, and the question has been debated whether the fixed radiants cannot be explained by successive showers accidentally placed in nearly the same apparent points of the firmament. After investigating the observational part of the subject as fully and carefully as circumstances allowed, I found that, allowing for trivial errors in determining positions, the showers occurred from identical centres, and certainly could not be ascribed to chance grouping.

A large proportion of the observed radiant points are of this fixed and long-enduring character. As a rule their individual meteors move with great velocity when the radiants are near the earth's apex, but, with increasing distance from it, their speed sensibly moderates, and they finally become slow, and very slow. Thus my stationary radiant at $47° + 44°$ yields *very swift* streak-leaving meteors in July and August, while in November and December they are *very slow*. But this peculiarity is not exemplified in all cases, for there is a shower at $61° + 49°$ which discharges very swift meteors at the end of November and early in January, whereas in September I have recorded them as *swift*. This is, however, an exception, and the rule appears to be that the showers meeting the earth give swift meteors, while those overtaking it give slow ones. It is clear from the varied phenomena observed both in the major and minor systems, that one and the same explanation will not suffice to explain them all, for every possible diversity of meteor shower may exist and display radiation in the firmament. We may find sporadic meteors of great velocity, and coming from distant space. There may be hyperbolic, parabolic, and elliptical streams, also meteors comparatively isolated, and forming the remnants of past groups dismembered by planetary perturbations, for the vicissitudes which these small bodies encounter must be very considerable. Some of the elliptical streams are very wide, and of this the August Perseids, with their shifting radiant, afford a prominent instance. The apparently stationary shower which I have seen at various times, coinciding in position with that of the Perseids on August 10th, is, of course, entirely different in character to the cometary shower, and needs a different explanation. The latter presents a vastly richer display as well as a moving radiant, and these features readily distinguish it from contemporary showers.

We require a vast amount of additional observation in this field. If an energetic observer, living in a finer climate than England, took up the subject, and watched the sky assiduously for several years, he would undoubtedly obtain sufficient data to clear up some of the features which now present such difficulties. I do not think the results of past observation would be controverted, but that the new evidence might enable satisfactory theories to be formed.

As to the accuracy with which radiant points may be determined, I believe that observers of long experience are likely to be the best judges of this. The probable error is different in different cases, for scarcely any two observers exhibit the same degree of skill. Training would never make some individuals accurate in this difficult branch of work. It takes fully two years of habitual observation before anyone can acquire desirable proficiency in recording meteors, and confidence in assigning their radiants. Speaking for myself, I believe my positions are within 2°, and frequently within 1°, of the real centres. I should regard 2° as a *large* error in ascribing the radiant of a well-defined meteor shower. The Andromedes of November 27th, with their widely-diffused radiant, form a very exceptional shower, from which it would be unsafe to judge of the character of others. Many of the minor systems exhibit contracted and sharply-defined radiants which may be accurately determined by the careful observer.

Yours faithfully,

Bristol, May 20th, 1891. W. F. Denning.

METEOR-RADIANTS

To the Editor of Knowledge.

Sir,—I am afraid that I cannot throw any light on the limits of error as regards the determination of meteor-radiants. It would be interesting if three or four practised observers would make their observations on the same night, at the same place, and then compare their results. But whatever the limits of error may be, I do not see that errors would, on the whole, produce a greater clustering of meteor-radiants than if the positions were accurately known. I should add that Mr. Denning's catalogue contains only positions determined by observations on a single night. But he has a column entitled "Other nights of observation," *i.e.*, other nights on which meteors were observed as coming from the radiant thus determined, which I used in my previous letter. The number of meteors used in determining the radiant is in each case mentioned in his catalogue.

I did not intend to maintain that these stationary or long-enduring radiants are in all cases active throughout the year. The evidence, at present, at least, does not go that far. But the reasons for not observing meteors from particular radiants at certain seasons of the year are pretty evident. We cannot expect to trace such meteors when

the radiant point is below the horizon or near the horizon at the usual hours of observation; and as Mr. Denning tells us that he made nearly all his observations looking East, meteors from radiants in the West would naturally be passed over. Further, I do not think that where the radiant is of this long-enduring or stationary character, the shower is of uniform intensity throughout. On the contrary, so far as I have traced, the maximum of each long enduring shower occurs nearly at the same date in successive years. The showers appear, moreover, to be more intense in some years than in others.

I wish to state in conclusion, that I never disputed in any way the accuracy of Mr. Denning's observations. I only differ from him as to the classification and arrangement of some of them.

Truly yours,
16, Earlsfort Terrace, Dublin. W. H. S. MONCK.

THE FACE OF THE SKY FOR JUNE.

By HERBERT SADLER, F.R.A.S.

THE increase in solar activity still continues. During June there is no real night in the British Islands. There will be an annular eclipse of the Sun on the afternoon of the 6th, which will be visible as a partial eclipse at Greenwich. At that station the eclipse begins at 5h. 2.2m. P.M., the first contact taking place at an angle of 88° from the vertex towards the west, reckoning for direct image; the middle of the eclipse being at 5h. 46·7m. P.M.; and the last contact taking place at 6h. 23·6m. P.M., at an angle of 5° from the vertex towards the west; the magnitude of the eclipse being 0·238. With the exception of an exceedingly small eclipse on the morning of March 26th, 1895, the next solar eclipse visible at Greenwich will not take place till June 8th, 1899.

The following are conveniently observable times of minima of some Algol type variables (*cf.* "Face of the Sky" for April and May): U Cephei.—June 2nd, 10h. 29m. P.M.; June 7th, 10h. 9m. P.M.; June 12th, 9h. 49m. P.M.; June 17th, 9h. 28m. P.M.; June 22nd, 9h. 8m. P.M. S Cancri.—June 14th, 10h. 22m. P.M. δ Libræ.—June 14th, 0h. 26m. A.M.; June 18th, midnight; June 27th, 11h. 35m. P.M. U Coronæ.—June 20th, 11h. 49m. P.M.; June 27th, 9h. 31m. P.M. U Ophiuchi (17h. 10m. 57s. + 1° 20′).—Max., 6·0 mag.; min., 6·7 mag.; period, 0d. 20h. 7m. 41·60s.—June 4th, 10h. 17m. P.M.; June 9th, 11h. 3m. P.M.; June 14th, 11h. 48m. P.M.; June 15th, 7h. 56m. P.M.; June 20th, 8h. 41m. P.M.; June 25th, 9h. 28m. P.M. Y Cygni (20h. 47m. 47s. + 34° 15′).—Max., 7·1 mag.; min., 7·9 mag.; period, 1d. 11h. 56m. 48s.—June 2nd, 10h. 6m. P.M.; June 5th, 10h. 1m. P.M.; June 8th, 9h. 56m. P.M.; June 11th, 9h. 51m. P.M.; June 14th, 9h. 45m. P.M.; June 17th, 9h. 40m. P.M.; June 20th, 9h. 34m. P.M.; June 23rd, 9h. 28m. P.M.; June 26th, 9h. 23m. P.M.; June 29th, 9h. 18m. P.M. Variable, of short period, not of Algol type. η Aquilæ (19h. 46m. 52s. + 0° 43′). Max., 3·5 mag.; min., 3·7 mag.; period, 7d. 4h. 14m. 0s. June 27th, 9h. P.M. Maximum of R Hydræ (*cf.* "Face of the Sky" for February, 1889) on June 1st. The lines of hydrogen in the spectrum of this star appear bright near maximum.

Mercury is a morning star throughout June, but owing to his proximity to the Sun and the strong twilight prevailing he is not very favourably situated for observation. He rises on the 1st at 3h. 13m. A.M., or 38m. before the Sun, with a northern declination of 13° 26′ and an apparent diameter of $8\frac{3}{4}''$, just three-tenths of the disc being illuminated. On the 16th he rises at 2h. 48m. A.M., or 56m. before sunrise, with a northern declination of 18° 53′, and an apparent diameter of $6\frac{1}{2}''$, six-tenths of the disc being then illuminated. On the 30th he rises at 3h. 9m. A.M., or 38m. before the Sun, with a northern declination of 23° 54′. and an apparent diameter of $5\frac{1}{4}''$, $\frac{95}{100}$ of the disc being then illuminated. He is at his greatest western elongation ($23\frac{3}{4}°$) on the evening of the 5th. During the month he passes from Aries throughout the whole length of Taurus into Gemini, but without approaching any conspicuous star very closely. Venus is also a morning star this month, but her observation is rendered difficult by the same conditions which militate against the visibility of Mercury. She rises on the 1st at 2h. 45m. A.M., or 1h. 6m. before sunrise, with a northern declination of 13° 47′ and an apparent diameter of $11\frac{1}{2}''$, $\frac{87}{100}$ of the disc being illuminated. On the 30th Venus rises at 2h. 24m. A.M., or 1h. 23m. before the Sun, with a northern declination of 22° 1′ and an apparent diameter of $10\frac{1}{2}''$, $\frac{93}{100}$ of the disc being then illuminated, and the brightness of the planet being only one quarter of what it was on January 8th. During the month she passes from Aries into Taurus. Mars is invisible.

The minor planet Vesta (*cf.* "Face of the Sky" for January, 1890) comes into opposition on the 23rd, and but for her great southern declination would be excellently placed for observation, as, with one exception, this is the closest approach to the earth that she has made during the last thirty years. Her distance from us at opposition is about 106,655,000 miles, and she is visible to the naked eye during the whole of June, though the proximity of the nearly full Moon at the actual date of opposition will interfere with naked eye observation. At the present opposition she attains to the 6·0 magnitude, and it is to be hoped that search will be made with powerful telescopes in the South of Europe and the United States, both by means of photography and by eye observations, for a possible satellite. On the day of opposition she souths at midnight with a southern declination of $20\frac{3}{4}°$, her apparent diameter being about $1\frac{1}{2}''$. A map of the path during the month will be found in the *English Mechanic* for May 8th. As Jupiter does not rise till 11h. 9m. P.M. on the last day of the month, and as none of the satellite phenomena are visible at Greenwich till after midnight, we defer an ephemesis of him till July. Saturn is an evening star, but is nearing the west so rapidly that he should be looked for as soon as possible after sunset. He sets on the 1st at 1h. 9m. A.M., with a northern declination of 9° 27′ and an apparent equatorial diameter of $17\frac{1}{2}''$ (the major axis of the ring-system being $40\frac{1}{4}''$ in diameter, and the minor $3\frac{3}{4}''$). On the 30th he sets at 11h. 13m. P.M. with a northerly declination of $8\frac{3}{4}°$, and an apparent equatorial diameter of 16·6″ (the major axis of the ring-system being $38\frac{1}{4}''$ in diameter and the minor 3″). On the 4th Iapetus is near his greatest eastern elongation, where he is faintest. On the evening of the 6th Titan is eclipsed by the shadow of Saturn, the middle of the eclipse taking place about 7h. 30m. P.M., and the satellite is again eclipsed on the evening of the 22nd, the middle of the eclipse being at about 6h. 45m. P.M. Iapetus is about 36″ north of Saturn on the evening of the 23rd. Saturn is in quadrature with the Sun on the 1st, and describes a short direct path in Leo during June, but does not approach any conspicuous star. Uranus rises on the 1st at 3h. 52m. P.M., with a southern declination of 10° 11′ and an apparent diameter of 3·6″. On the 30th he rises at 1h. 55m. P.M., with a southern declination of 10° 1′, and an apparent diameter of 3·6″. He describes a very short retrograde path to the N.N.E. of 86 Virginis during the month. Neptune is invisible.

There are no very well marked showers of shooting stars in June.

The Moon is new at 4h. 26m. p.m. on the 6th; enters her first quarter at 0h. 34m. p.m. on the 14th; is full at 5h. 12m. a.m. on the 22nd; and enters her last quarter at 11h. 16m. p.m. on the 28th. She is in apogee at midnight on the 13th (distance from the earth, 251,225 miles); and in perigee at 5h. a.m. on the 26th (distance from the earth 228,350 miles). The greatest western libration takes place at 3h. 0m. p.m. on the 7th, and the greatest eastern at 3h. 17m. a.m. on the 20th.

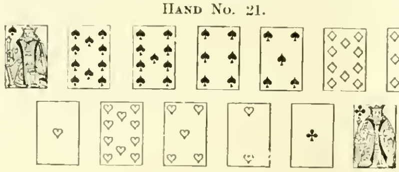
Whist Column.

By W. Montagu Gattie, B.A.Oxon.

Declining to Draw the Losing Trump.

The situation in which it is bad play to draw the losing trump is usually defined in the text-books as that in which one adversary has a long suit established, while his partner holds a card of that suit and also the losing trump. Another and somewhat more complicated case arises when the holder of the losing trump, although void of the established suit, can lead another suit in which his partner has a card of re-entry. This is illustrated by the following hand—

Hand No. 21.



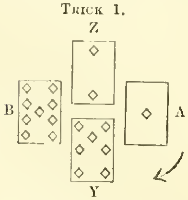
Y's Hand.

Score—Love all.

Z turns up the seven of hearts.

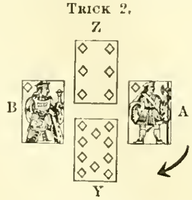
Note.—A and B are partners against Y and Z. A has the first lead; Z is the dealer. The card of the leader to each trick is indicated by an arrow.

Trick 1.



Tricks—AB, 1; YZ, 0.

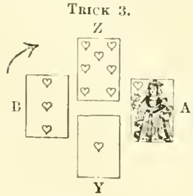
Trick 2.



Tricks—AB, 2; YZ, 0.

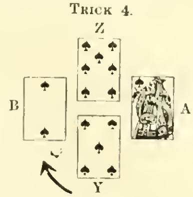
Note.—The only diamond Z can have is the eight; A has the rest, unless B has begun a call for trumps.

Trick 3.



Tricks—AB, 2; YZ, 1.

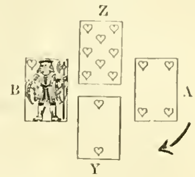
Trick 4.



Tricks—AB, 3; YZ, 1.

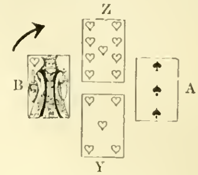
Note.—*Trick* 4.—With trumps declared against him, and an adverse suit already established, Y prefers not to open with his fourth best spade. The fall of the cards shows that Y has the knave of spades.

Trick 5.



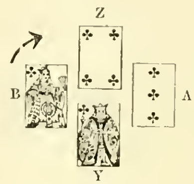
Tricks—AB, 4; YZ, 1.

Trick 6.



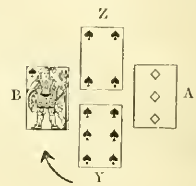
Tricks—AB, 5; YZ, 1.

Trick 7.



Tricks—AB, 5; YZ, 2.

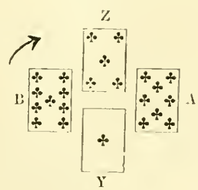
Trick 8.



Tricks—AB, 6; YZ, 2.

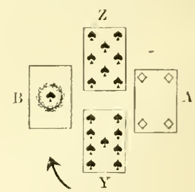
Note.—*Trick* 8.—Y retains his trump to ruff the diamonds, in case A should have the ace of spades. After this trick it is clear that A can only bring in the diamonds by winning a trick in clubs.

Trick 9.



Tricks—AB, 6; YZ, 3.

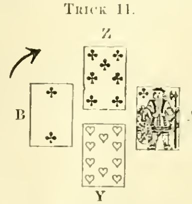
Trick 10.



Tricks—AB, 7; YZ, 3.

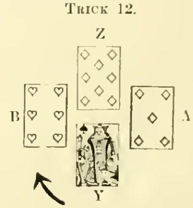
Note.—*Trick* 10.—If Y now draws the trump, and A should afterwards be found with the best club, he will make that and the queen of diamonds, and AB will win the game. Z's only possible spade is the eight; and, as he can only have one diamond, he must have four clubs, of which one must be either knave or ten.

Trick 11.



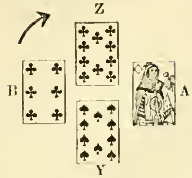
Tricks—AB, 7; YZ, 4.

Trick 12.



Tricks—AB, 8; YZ, 4.

Trick 13.



Tricks—AB, 8; YZ, 5.

AB Score Two by Cards and Two by Honours, and YZ Save the Game.

A's Hand.	B's Hand.
H.—Qn, 4.	H.—Kg, Kn, 6, 3.
S.—Qn, 3.	S.—Ace, Kn, 2.
D.—Ace, Qn, Kn, 5, 4, 3.	D.—Kg, 9.
C.—Kn, 8, 3.	C.—Qn, 9, 6, 2.

Y's Hand.	Z's Hand.
H.—Ace, 10, 5, 2.	H.—9, 8, 7.
S.—Kg, 10, 9, 6, 5.	S.—8, 7, 4.
D.—10, 7.	D.—8, 6, 2.
C.—Ace, Kg.	C.—10, 7, 5, 4.

Remarks.—At trick 7 B argues that he cannot win the game unless he and A can make two tricks in clubs, or unless A can bring in the diamonds. Neither result is at all probable unless A holds an honour in clubs, and in that case it is clearly better that B should clear the way by leading his queen. B therefore treats his long suit as if it were a short one, but his tactics are defeated by Y's refusal to draw the trump. It will be found on trial that B would do no better by leading a small club.

Chess Column.

By C. D. Locock, B.A.Oxon.

The Proprietors of this Journal propose to offer a set of Staunton Chessmen and Box, by way of prize for a Knowledge Chess Problem Tournament, in connection with this Column. The Competition will begin with a problem in the July number. Six problems will decide the result, unless a tie should necessitate one or two more contests. The score will be reckoned by points, as follows:—

Two-move problems:—For correct key-move, 3 points; variations unnecessary.

Three-move problems:—For correct key-move *and second moves*, 8 points. *Two points will be deducted for each second move omitted or incorrect.* Solutions must be sent in by the 10th of each month. Should a problem admit of a second key-move, *two* additional points will be awarded for the discovery in the case of two-move problems, and *four* additional points in the case of three-move problems. *The same number of marks will be deducted should the claim be incorrect.*

Intending competitors are invited to send for insertion *one* problem of their own composition, not previously published.

The composer will score full marks for the solution of his own problem, if inserted; but if other solvers should find a second solution, he will score *none*.

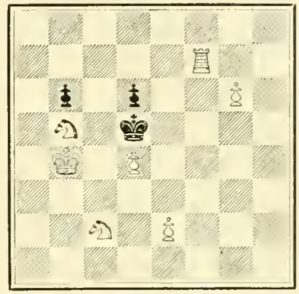
To Correspondents:—*C. T. Blanshard.* Q to R6 will not solve Mr. Mortimer's problem. After 1. . . . Kt to K3, 2. Kt to Kt6, K × Kt, there is no mate. Also after 1. . . . Kt to Ksq, 2. Q to B8, Black saves the mate by 2. . . . Kt to Q3!, not to mention the check with the Rook.

A. J. Luisham. If 1. Q to R6, Kt to K3; 2. Q × Kt, R to K2!, pinning the Queen.

Solution of Problem (*By J. Mortimer*). 1. Q to R7, Kt to K3, 2. Kt to Kt6, etc. The other variations are obvious. This is, strange to say, the only problem which Mr. Mortimer has composed.

PROBLEM.

Black.



White.

White to play, and mate in two moves.
(A very easy practice problem.)

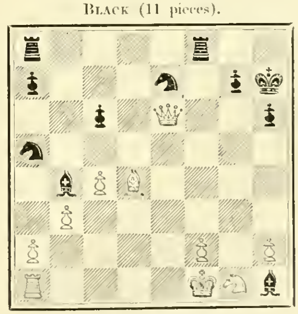
CABLE MATCH.

Below is given the remainder of our analysis of the "Two Knights" Game.

Position after Black's 27th Move.

M. TSCHIGORIN.

Black (11 pieces).



White (10 pieces).

W. STEINITZ.

White. (Steinitz.)	Black. (Tschigorin.)
28. Q to B3 (*s*)	28. Kt to B4
29. B to K5 (*t*)	29. QR to Ksq
30. B to B4 (*u*)	30. Kt to Q5 (*v*)
31. Q to Q3ch (*w*)	31. B to K5
32. Q × Kt (*x*)	32. R × B
33. P to B3 (*y*)	33. QR to KBsq
34. Q × RP	34. P to B4! (*z*)
35. Q to QB7 (1)	35. Kt to B3
36. P to QR3	36. R × Pch (2)
37. Kt × R	37. R × Ktch
38. K to Ktsq	38. BQ7
39. Resigns (3)	

Notes.

(s) Mr. Steinitz rightly decides to act strictly on the defensive. The object of this move is chiefly to defend the QKtP in case he gets time for P to QR3. It also allows a check at Q3, in case of need. He dare not play immediately 28. P to QR3 on account of 28. . . . KtB4 ! ; 29. BKt2 (after 29. P × B, Kt × B, Black wins easily) ; 29. . . . QRKsq ; 30. QQ7, KtK6 ch ; 31. KK2, KtQ8 ! dis. ch. mating or winning the Queen.

(t) 29. BKt2, QRKsq, would leave him no defence. Nor could he allow the Bishop to be exchanged at K3.

(u) Obviously, if 30. PKB4. R × B, 31. P × R, KtKt6 mate. 30. BKt3 would also lose speedily.

(v) Preventing KtK2. After 30. . . . RK5 ; 31. KtK2, KtQ5 ; 32. Kt × Kt, QR × B ; 33. KtK6, R × P ch ; 34. KKtsq, KRB6 ; 35. QR4, Black has to waste time in freeing his Bishop.

(w) For QKt3 see note (x). If 31. B × P, P × B ; 32. QQ7 ch, RK2 ; 33. Q × Kt, RKKtsq wins, as pointed out in the *Daily News*.

(x) 32. QKt3 loses by PKKt4 ; 33. BBsq ! (otherwise KtB4 followed by PKt5 wins at once), 33. . . . KtB7 ch winning the exchange.

(y) Not Q × RP on account of . . . . RKt5, 34. PB3, BQ6 ch, and 35. . . . RKt4.

(z) Shutting out the Queen for the remainder of the game. Mr. Tschigorin judiciously reserves the capture of the KBP. After the exchange of pieces Black has only one check, for the Queen could sacrifice herself for two Rooks.

(1) 35. PQR3 is useless on account of KtB3 (not Kt × KtP ; 36. P × B, R QRsq. ; 37. Q × R, etc.)

(2) A beautiful and unexpected move, which forces a win in a few moves.

(3) QKt6 is the only move to save the Queen. Black would then mate in six moves.

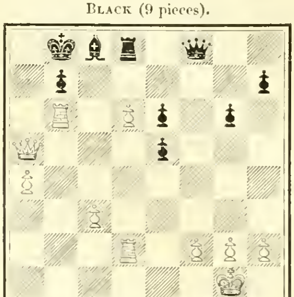
Mr. Tschigorin's play throughout could hardly be improved on.

The Evans Gambit was also resigned by Mr. Steinitz at the same time.

Only one move on each side was made since the publication of the diagram in the May number, viz., 36. . . . K to Ktsq. ; 37. P to Q6.

Diagram of the final position.

Black (9 pieces).



White (10 pieces).

Black resigns.

[For if 37. . . . Q to B5 ; 38. R × P ch, B × R (K × R leads to the loss of the Queen in four more moves) ; 39. Q × R ch, K to R2 ; 40. Q to B5 ch, BR3 (otherwise the Pawn goes to Queen) ; 41. Q to B5 ch ; and 42. Q to K3, winning easily.]

Mr. Steinitz has put his two most recent eccentricities to a crucial test, with an unsatisfactory result. The two defences are not only purposeless, but, as pointed out in the *Chess Monthly*, inconsistent with each other. In the one case Mr. Steinitz moves a piece to a bad square in order to be attacked ; in the other case he does the same thing in order *not* to have the piece attacked. In each case the defence is made more difficult than is necessary.

Theory of the Chess Openings. By G. H. D. Gossip. (Messrs. W. H. Allen & Co.) This, the author's third treatise on the subject, is the latest contribution to English chess literature. The book is of prepossessing exterior, the brilliant colour of the binding being rendered still more brilliant by a diagram of what is variously described in the introduction as "Mr. Gossip's historically magnificent performance," or, more briefly (but in larger type), Gossip's Brilliant Mate. [This is a position taken from a game in the American Tournament of 1889, which, in Mr. Gossip's opinion, should have taken the brilliancy prize.] The author has adopted, for the first time, the column arrangement of variations. The experiment is not altogether a success : the columns appear to have been arranged regardless of natural sequence, and in at least one case have been repeated word for word. The analytical portion of the work is satisfactory on the whole. Perhaps Mr. Steinitz has been too unquestioningly followed. The author might certainly "venture to differ" more often than he does. The work is mainly, as it professes to be, a compilation from all the modern sources, but much of it is the author's own. Especially noticeable is the adequate treatment of the Vienna opening, several branches of which have been hitherto strangely neglected. The book teems with personal controversy, more entertaining than instructive, vindication of capability being the main topic ; but, judged simply from a chess point of view, it is of undeniable value, being exhaustive and thoroughly up to date. The price is extremely moderate, and the printing and binding excellent.

Contents of No. 67.

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CONTENTS.

NOTICE.

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GNATS, MIDGES AND MOSQUITOS.—I.

By E. A. BUTLER.

UNDER these names are included a variety of small, delicately constructed flies, the very types, in the insect world, of slenderness, grace, and fragility. But fairy-like elegance of form is no guarantee of gentleness of disposition, and it is united, in the case of *some* of these insects, with a persistence and hardihood in attack, and a bloodthirstiness of nature, that make them some of the most intolerable of pests. In this country, it is true, we are now, for reasons which will appear later on, tolerably free from annoyance on their part; but as they are world-wide in distribution, ranging from the tropics to the Arctic zone, there are many less-favoured lands, in which they still exist in countless myriads, and in which their extermination would be hailed, whether justifiably or not, as an unmixed blessing. They form a sub-section of the enormously extensive order of Diptera, or two-winged flies, an order which is probably responsible for the infliction of a larger amount of suffering and annoyance upon human beings and other vertebrate animals than can be charged upon any other. At least two very distinct types of Diptera may be recognised; on the one hand, there are stout-bodied and comparatively short-legged flies, with minute and curiously shaped antennæ like those of the blow-fly, and on the other, slender-bodied exceedingly long-legged flies, with antennæ of ordinary size and of less extraordinary shape. To the former division (*Brachycera*=short-horns) are referred the house-flies and allied insects discussed on a former occasion in our papers on "House-flies and Bluebottles," as well as hosts of others less familiar; while to the latter (*Nemocera* =thread-horns) belong a weak-limbed and fragile group, the daddy-long-legs or crane-flies, together with the numerous kinds of gnats, mosquitos, midges, merry-dancers, &c. (though not the equally, or even still more, fragile May-flies or day-flies). It is with the section Nemocera, therefore, viz. the "thread-horned" flies, that we are now concerned.

There is amongst the members of this group a striking variety, both as to habits and life-history. Some, in their early stages, lead an active life in the water; others, of a more sluggish temperament, inhabit fungi or rotten wood; others, again, like the notorious Hessian fly, are parasitic on plants, producing gall-like excrescences within which they reside; while yet others, like the daddy-long-legs, whose larvæ are the detested "leather-jackets" of the gardener, live underground, devouring roots of plants as well as vegetable refuse. It might be expected that, with such diversity of habits, there would be correspondingly great differences of form in the adult insects. Such, however, can scarcely be said to be the case, and thus many that are superficially similar in the adult condition may have passed through their preliminary stages under totally different circumstances. This fact, coupled with the fragile and easily damaged structure, and consequent difficulty of preservation, the obscure colours, and the comparatively unmarked characters of the perfect insects, makes the nice discrimination of species a very difficult task, and it is not surprising that the popular judgment has declined this task, and has seen in all these different creatures but varieties for which three or four names at the outside will suffice. Our first business, therefore, must be, as is usually the case in dealing with insects under their popular names, to define our terms, and to say what insects we include and what we exclude, and in what sense we use the terms "gnats, midges, and mosquitos."

Without in the least attempting accurately to distinguish species, it may suffice to say that, when we speak of gnats and mosquitos as household pests, we do not by any means refer to all gnat-like creatures, nor even to all which would commonly be called gnats, but only to such as belong to one particular family, the *Culicidæ*, and which, by their blood-sucking propensities, trouble mankind indoors, either in this country or elsewhere. Nor shall we draw any definite line of distinction between gnats and mosquitos. It is often imagined that mosquitos are creatures confined to warm climates and having nothing to represent them in this country; but the fact is that the difference between a gnat and a mosquito is little more than one of name. To an entomologist they are practically the same thing; both are members of the same genus, *Culex*, and the difference

is, at the outside, not more than that between closely allied species. It is true that the virulence of the "bite" of these creatures in tropical countries is much greater than it is here; and, when one remembers the frightful effects that are sometimes produced on the human body by these little pests, and the strenuous efforts that are made, and the elaborate precautions that are taken, whether in the way of oily unguents, of curtains and nets, or even of burying the body in the sand, to guard against their attacks, it is no doubt disappointing to discover that after all there is nothing so very remarkable in the creatures, and that they can hardly be distinguished from insects with which we are familiar at home. Nevertheless, it is a fact, which we must constantly bear in mind, that the insects to which these names are applied are to all intents and purposes identical both in structure and in life-history, and we are therefore justified in making no distinction here. Moreover, there is no doubt that, even in the matter of virulence, our own gnats vary a good deal, both according to season and to the temperament and sensitiveness of the person attacked. We must not, however, fail to note that there are other flies, belonging to different families, that are also blood-suckers, and in some cases are almost as troublesome as the true gnats and mosquitos. This is specially the case with the small flies called *Simulia*, which are closely allied to the family *Culicidæ*, and are, it would appear, sometimes called mosquitos in America. Such insects, however, are not referred to here, and what we have to say about "gnats and mosquitos" concerns only the family *Culicidæ*, and, in fact, the genus *Culex*.

Of the term "midges" it is somewhat more difficult to fix the application; it is indiscriminately used of at least two types of flies, quite distinct from one another, one, in most respects except persecuting powers, similar to the gnats and mosquitos, the other very different in appearance, and at first sight more like tiny moths than flies; but it appears also to be popularly used in a loose manner for small and annoying insects of whatever kind, without any definite conception as to the actual form intended. It is obvious, therefore, that when the entomologist hears people talking vaguely of gnats and midges, it is not always easy to understand exactly what insects are being referred to.

With these preliminary precautions, and bearing in mind that not every small, long-legged, fragile fly is a gnat in the sense in which the word is here used—*i.e.*, a blood-sucking gnat—we may now proceed to consider first what sort of being a blood-sucking *gnat* or *mosquito* really is, referring afterwards to those which seem to be more correctly called *midges*. The photographs on the accompanying page will give a pretty good idea of the general form of a gnat. A small head, a considerable portion of which is occupied by the compound eyes, is attached by means of a short neck to a huge globular thorax, so disproportionately large as to give the insect, when viewed sideways, a hump-backed appearance. Behind this the trunk is completed by a long, slender, cylindrical abdomen. A long, straight, beak-like appendage, carrying the mouth organs, points forward from the head, and a pair of more or less tufted, thread-like antennæ form an excellent head-gear, counterbalancing this above. From the upper part of the thorax spreads at each side a single membranous wing, exquisitely delicate, and gracefully fringed along its hinder edge; the place of the customary second pair is taken by the "poisers," long knobbed stalks, as already described in the other division of flies, but proportionately much larger than in those. From the under surface of the thorax start the three pairs of inordinately long legs, upon which, when at rest, the body is, as it were, slung up off the ground, as if on springs. Though the legs consist only of the ordinary parts, yet the divisions seem at first sight to be more numerous than usual, by reason of the great proportionate length of some of the parts, and particularly of the tarsi, or feet, which in the hind pair constitute more than half the entire length of the leg, the leg itself becoming nearly three times as long as the abdomen. The insect is beautified by the addition, on various parts of the body, of minute iridescent scales (Fig. 1), similar to those of butterflies and moths; rows of them adorn the wings, especially along the nervures.

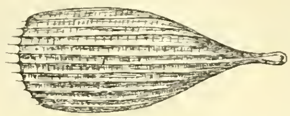
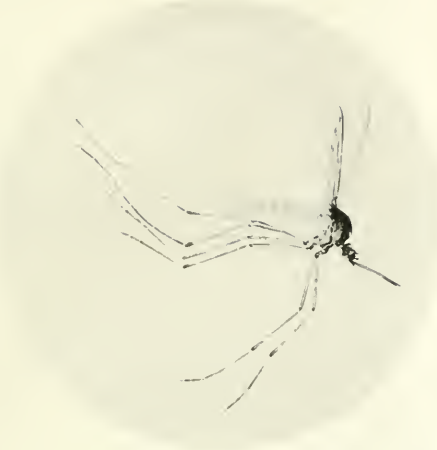


Fig. 1.

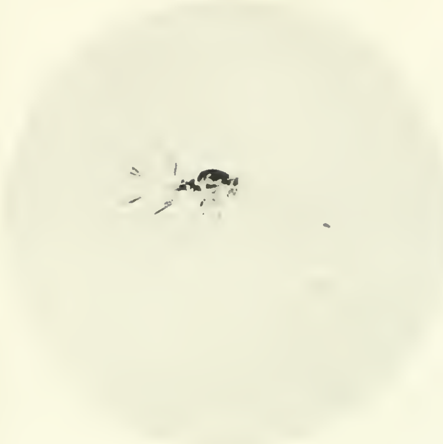
A marked difference appears between the sexes. The male can be distinguished by the extraordinary development of the antennæ, which, as frequently in insects of that sex, are, if one may judge from their structure, far more delicate organs of sense than those of his mate. The antennæ of the female consist of a string of cylindrical joints like long beads, each provided with a circlet of fine hairs of no very great length. Those of the male, however, while similarly constructed, have the brushes much longer and more thickly set, especially at the base, for the extreme tip is almost bare. In the photograph the hairs of the female are indistinct through their extreme tenuity, and the charming symmetry of form and arrangement which those of the male naturally exhibit is unfortunately destroyed because the insects have been preserved in balsam, and it is impossible then to ensure that appendages so delicate should be spread out with all the hairs in proper position; no conception, therefore, of their great beauty can be formed from a specimen so preserved.

The greatest interest, of course, attaches to the proboscis, for herein are contained the weapons of attack. In this, again, the sexes differ greatly, and it is against the female only that the charge of blood-sucking can be substantiated. The male is an inoffensive creature, and usually remains in his native haunts, not invading our apartments; for it must be remembered that these flies, like those treated of before, pass their early stages out of doors and enter our houses only when fully grown. The straight, cylindrical spike projecting from the head, though itself no thicker than a hair, is a tube, or rather trough, terminated by two small fleshy lips, the dwarfed representatives of the two large folding leaves which terminate the proboscis of the blow-fly. This tube represents the labium of the normal insect's mouth, and concealed within it lie the much finer *piercing* organs; for the so-called "bite," like that of the bed-bug, consists really of a boring and sucking operation. Along by the upper slit of the trough lies a long bristle-shaped organ, which represents the labrum, or upper lip, and of course all the rest of the mouth organs, except the palpi, lie between this and the labium, *i.e.*, in the trough of the latter. The mandibles and maxillæ, which in insects that feed on solid food are efficient biting weapons, are here, as in the bed-bug, replaced by four fine-pointed, needle-like bristles, the maxillæ being further barbed at the tip like a savage's spear, and the mandibles slightly broadened into a lancet-shaped tip. Besides these, another piercing bristle is found, which is an appendage of the labium itself. Thus there are no less than six boring organs, all contained within a sheath which is itself almost of hairlike fineness. The sheath itself, like so many other parts of the body, is beautifully ornamented outside with abundance of battle-dore-shaped scales. At its base are two short jointed



Female Gnat or Mosquito, magnified about five diameters.

The rod-like projection from the head is the labium, from which one of the stylets, probably the labrum, is separated beneath; the other piercing organs lie within it. The minute maxillary palpi can be seen at the base of the labium as two little dark streaks, one above, the other below. The nervures of the wings look thick and cloudy because of the scales that lie along them. This insect "bites," i.e., sucks blood.



Male Gnat, magnified about five diameters.

The rod-like labium is seen as in the female, but the maxillary palpi are enormously elongated, and are broadened and fringed at the tip like two clubs, above and below the labium. The antennæ are deeply fringed. This insect does not "bite."

Larva of Gnat, magnified about ten diameters.

The broad head and thorax are followed by the cylindrical body, in which the dark digestive tube is seen. At the lower end (tail) a branch projects at an angle, carrying within it the main trachea or breathing tube, the entrance to which is at the extreme tip on the left.

Pupa of Gnat, magnified about ten diameters.

The tail is furnished with two transparent steering and swimming paddles, and from the back of the thorax arise, as two horns, the two openings to the breathing apparatus (thoracic spiracles). Legs and wings can be seen folded up under the thin transparent skin of the thorax.

MALE AND FEMALE GNAT OR MOSQUITO, with Larva and Pupa, from photographs lent by Newton & Co., of Fleet Street.

organs, the maxillary palpi, representatives of the two unjointed red clubs which are such conspicuous appendages of the mouth of the blow-fly. This straight, unjointed spike is, at first sight, as different as could well be imagined from the elbowed, broad-tipped apparatus with which the house-fly and the blow-fly sip their liquid nutriment; yet both are but extreme modifications of the same plan, the rasping and sucking elements being carried to the summit of perfection in the one case, and the boring or piercing ones in the other. Many intermediate forms may be seen, as in the drone-flies, breeze-flies, wasp-flies, and others which have no popular names, and a very interesting series showing the gradations might without much difficulty be prepared.

Now how is this collection of weapons used? The little insect drops gently and daintily down on to the spot it has selected for its attack, and the descent of so light and airy a being is likely to leave the victim unconscious of its presence, unless he has actually seen it settle. Then the proboscis is pointed downwards, and the tiny lips that form its tip pressed against the flesh. The bristles within the gutter-like sheath, being then pressed together into one solid boring implement, their common tip is forced down on the flesh, and as they enter the wound, the trough in which they were lying separates from them in the middle, and becomes bent towards the insect's breast, the two little lips all the while holding on tight. The greater part of the length of the stilettos is then plunged into the victim's flesh, and the blood is drawn up the fine interstices of the composite borer. The wound, though six instruments are concerned in making it, is extremely minute.

So far, our description has concerned the proboscis of the *female* gnat or mosquito only. That of the male is somewhat different. There is still the straight stick-like labium, but the palpi are greatly elongated, running along by the sides of the tubular proboscis as far as, or even beyond, its tip, and tufted at the end. A fine rod-like organ may be separated from the labium, but whatever else the insect may have in this way, it does not use for sucking blood, being in fact perfectly harmless.

In their earlier life these insects inhabit ponds and stagnant water generally. The larva and pupa are shown in the accompanying photograph. The former, an odd-looking, big-headed, wriggling creature, swims about head downwards, devouring all sorts of organic refuse in the water, coming to the surface to breathe through the opening at the end of the tail-branch. The pupa also swims about, but with its head upwards, and though active, it takes no food. It requires to come to the surface occasionally for air, which is taken in at the two little projecting horns on the thorax. Fuller details of these early stages and of the entire life-history must be reserved for our next paper.

(*To be continued.*)

ON THE PLAN OF THE SIDEREAL SYSTEM.

By J. R. Sutton,* B.A., Cantab.

Many lines of circumstantial evidence go to show that the Milky Way is a ring-shaped formation, roughly circular in section, one of the most important depending upon the almost obvious connection between the lucid stars lying on or near the galactic belt and the nebulous looking matter of which it consists. It scarcely needs demonstration that all these lucid stars are not necessarily *galactic* (under which term we include all stars actually within the stream, or which, though outside it, are so near as to influence it to an appreciable extent), nor is it likely that the relation when it does exist will always be made out. Nevertheless, in many, perhaps the majority of cases, so far as the (optically) extra-galactic stars are concerned, the problem is not a difficult one for any person on whom the shadow of John Michell's mantle has fallen. Whenever, for example, a star or group of stars lies opposite or inside a gap in the profile of the Milky Way; or wherever any of its numerous branching lateral offsets terminate in the immediate vicinity of a bright star or star-group, we are entitled to assume, if the doctrine of chance has any credit at all, that these stars are intimately associated with, if they are not the agents which have determined the conformation of the stream, and they may therefore be considered a part of it.

When we come to deal with the stars optically upon the stream the problem is not quite so simple. Such stars may be either within the stream or without it, and, if the latter, may or may not be galactic. We know that the parts of the sky traversed by the Milky Way contain very many more bright stars than would be the case if the stars were uniformly distributed over the whole celestial sphere; and Probability interprets this to mean that the chances are enormously against a general dissociation between the two. This, however, is not exactly the same as *proving* a relationship. If it were, it would mean that all, or nearly all, the stars so situated are galactic. On the contrary, although the statement may be true in general, it is not possible to indicate at random any star or star-group as therefore forming part of the Milky Way.

Such details have to be decided independently, from particular and not from general considerations. The only instances we can be tolerably sure of are those (1) in which a stream of lucid stars and a nebulous streamer branch out together from the main course of the Galaxy, and turn to the right or left up to the apex of either without parting company; (2) in which a star or star-group lies in the midst of a small dark space surrounded by fields of normal brightness; and (3) in which stars are seen significantly mixed up with clustering aggregations of nebulous matter. In all cases of this nature there is no reason to doubt that the Galaxy and the lucid stars are mutually dependent.

There is no necessity just now to discuss these points at any greater length; that has been done elsewhere. They have been introduced, in brief, simply to indicate the principal lines of evidence made use of in the attempt to prove the ring-form of the Milky Way, and to avoid continual repetition in the course of this discussion.

It is clear that some of the clusters in the Milky Way might be streams of stars seen in projection.

Suppose an observer to select some star-group lying at the extremity of a straight galactic streamer, and then to take up such a position in space that his line of sight should pass through the group and along the axis of the streamer. If the streamer be supposed divided into sectional laminæ of the same thickness, these, taken singly, would be of the same intrinsic brightness however far off they might be; and in the case of a cylindrical stream their apparent size would vary inversely as the square of their distance from the observer. Hence the streamer would have, from the assigned position in space, the characteristics of a close globular cluster, its brilliancy decreasing gradually but rapidly towards its edges. Moreover, the lucid star-group at its apex would be pro-

* Mr. Sutton is at present in South Africa. His paper was forwarded from Kimberley with a letter in which he apologizes for writing on such a subject in the absence of books of reference. His ideas with regard to the association of the belt of great stars with the Milky Way were formed entirely independently and before he had seen my paper in the May number.—A.C.R.

jected into it, and so help to increase the impression of its being globular. The obvious inference is that we are unable to decide off-hand whether any single cluster is really a cluster or a drift of stars.

But such a theory with regard to the many clusters lying on the Milky Way would involve the existence of many straight streamers radiating towards our sun. If the Milky Way is a ring, and the sun occupies a central position, this might be possible, and the theory is supported to some slight extent by the behaviour of those apparent clusterings in the field of the Milky Way, whose brightness increases not towards their centres but from one side to the other, the magnitudes of the larger stars upon them following the same order. This is exactly what should happen in the case of a spicular projection *slightly* inclined to the line of sight. Other instances having the same tendency will readily occur to the student. But if any of the apparent clusterings are streaming appendages seen in perspective, we are met at the outset by the difficulty that none of them are so bright as we should expect; reasoning merely from first principles, their brightness is evidence enough that their length (if length they have) is small in comparison with the great arm stretching from Cygnus to Ophiuchus. The nebulous clouds in Aquila would certainly be darkness itself contrasted with the condensed brilliancy which would be exhibited by the spur in Scorpio to an observer situated on its produced major axis. Indeed the conspicuous cluster in the sword handle of Perseus offers the only possible comparable example. and not altogether a good one either.

It is necessary, then, to give up the assumption that any great galactic drifts lie within the space enclosed by the Milky Way, and pointing towards us. This may tend to shake our faith in a ring-form theory of the Milky Way—indeed in any of the present theories of its structure based on its streamy nature, such as Proctor's spiral theory; furthermore, according to the same reasoning, it seems probable that the great branch reaching to Ophiuchus, and the meanderings in Scorpio, are what they give the impression of being, namely, at approximately the same distance from us, and therefore parallel to the main course through Aquila and Sagittarius. We shall, however, have presently to consider this matter in another light when speaking on the probable position in space of the great appendages in Perseus and Cepheus. And incidentally we shall have reason to point out that the Milky Way is by no means obviously a stream of stars *of all sizes*.

Any theory which could account for the extraordinary evenness of outline of the Milky Way would have much in its favour. and this a ring theory has, as well as the spiral stream theory.

It is curious that the assertiveness of the Milky Way among the stars has always been tacitly recognized as a sign of its importance. Thomas Wright thought that its brilliancy represented the greater depth of the universe in its plane; and the two Herschels followed suit with different degrees of scepticism notwithstanding John Michell and his mathematical formulæ. Proctor thought that the Milky Way was a stream of stars of all sizes, all those scattered over the rest of the sky being in a sense sporadic, and not of any particular moment in modifying what he thought to be the architecture of the universe; and it must be admitted that his reproduction in one photograph of Argelander's forty charts might well seem to be very substantial grounds for the idea.

But although it is true that the Milky Way is richer in lucid stars than any area of equal size outside it, it is not true that it is the richest *great-circular belt* of the sky. That distinction is claimed by a belt arranged about a great circle through Cygnus, Perseus, Taurus, Orion, Crux, and Scorpio. Besides, the stars lying within it offer the clearest example of a star-stream it is possible to conceive. That it is a real star-stream is suggested first of all by its undeviating direction. A person standing under Orion will have overhead a most imposing arch of stars, springing with perfect symmetry from the horizon on either hand in Crux and Perseus without anything that can be called a break. Moreover, it passes across an exceedingly dark part of the sky. Below the horizon on the one hand it can be distinctly traced as far as ϵ and ζ Ophiuchi, where it seems to end, on the border of an empty space, sending out, meanwhile, a small arm from Crux, along the main course of the Milky Way as far as υ Sagittarii. In the same way, and as easily, we can trace the other continuation of the arch through Perseus, Cassiopeia, Cepheus, Cygnus, and Lyra almost or quite to α Ophiuchi on the other side of the empty space mentioned above. This end also sends out an arm in the direction of Aquila apparently as a feeler for the star. In one respect the great star-belt offers a curious analogy to the Milky Way: both are cut completely across, one in Ophiuchus, the other in Argo; and both spread out fan-wise on either side of the respective gaps, and to complete the resemblance, just as the nebulous magellanic clouds lie off, though having no defined connection with the gap in Argo, so do the apparently free star-groups of Ursa Major and Hercules lie off the gap in Ophiuchus.

Still these facts only suggest, and do nothing to prove, that the great star-belt actually marks the course of a real ring of stars in space. But there is a class of facts, well worth examination, which seems to place the matter beyond doubt.

First, then, if we trace the course of the Milky Way from Auriga through Monoceros we shall find it the most tame and unexciting object imaginable. It is as monotonous as an unvarying brightness can make it. With the solitary exception of β Tauri, no star of any magnitude occurs until we come to Argo, in which constellation the Milky Way and the great star-belt intersect at a very acute angle, so that the two are practically in company for a considerable space. Here there is a sudden metamorphosis: from being regular and unbroken the former becomes torn up into indescribable confusion—torn into ribbons so to speak, and it is pretty clear that the stars are the agents effecting the disruption, as we have shown elsewhere. For here we get all the associations referred to in the first two paragraphs of this article. Parting company with the stars (in Sagittarius) the Galaxy resumes very nearly its even outline and untroubled aspect until it intersects the star-belt again in Cygnus. Here the same phenomena of disruption recur.

Furthermore, there is not a galactic off-set of any size worth mention, whose shape, direction, and aspect are not determined by the stars in the great star-belt. The streamer in Perseus lies directly along, and that in Cepheus, across it. Those in Ophiuchus and Scorpio bend equally towards it. Indeed, the Milky Way itself, between Canis Major and Sagittarius, seems to have a decided double-warp of the same nature: curving round from either constellation perchance to come sooner into the plane of the star-belt. The spreading finger-shaped projections, facing each other across the gap in Argo, illustrate very forcibly the predominance of the latter in this respect.

Lastly, the area covered by the Milky Way is rich in lucid stars, because it crosses the richest parts of the star-belt. The conclusion seems to be emphatically forced

upon us that the great-star-belt is a genuine girdle of stars in space; in which, also, the foundations of the sidereal system are laid, the Milky Way being an appendant to it, of lesser rank. In short, the most noteworthy arrangement in the architecture of our universe seems to consist of a great ring of large stars intersecting an equal ring of small ones at the extremities of a common diameter. Let us recapitulate the evidence: To start with, we have the probability—shall we say certainty?—that the Galaxy is a ring-shaped structure, having, as we sought to show, no great branches in its own plane. Next, we have the significance of an almost entirely isolated, symmetrical belt of bright stars (stars singularly uniform in magnitude and distribution) encircling the whole heavens, and cutting the Milky Way in two exactly opposite parts. Then we have the striking suggestiveness of the disturbed state of the Milky Way in these parts, coupled with its evenness both in outline and aspect elsewhere. Lastly, we have the evidence derived from the affinity between the Milky Way and the stars in the belt; the galactic off-set in Perseus lying along the direction of the belt, the stellar off-sets from Cygnus to Aquila, and from Crux to Sagittarius, lying along the Milky Way; the galactic streamers, moreover, in Ophiuchus and Scorpio, nay, even the main stream of the Milky Way, turning aside to the star-belt just where the greatest angular distance separates them.

The double-ring structure enunciated above dovetails in with all these points; indeed, it seems the only logical deduction from them. Both Sir William Herschel's hypothesis of an even distribution of stars throughout our stellar system, and Proctor's spiral theory, fail utterly to account for the fact of a zone of bright stars associated with, but differentiated from, a zone of small ones in the manner observed. Further than this, the theory of a double-ring furnishes us with a rational explanation of the conspicuous absence of streamers round the interior face of the Galaxy, for it tells us where a powerful extraneous force is to be found counteracting altogether the action of the Milky Way upon itself.

THE EXPERIMENTAL METHOD IN GEOLOGY

By Vaughan Cornish, B.Sc., F.C.S.

The record of the investigation of a geological problem may generally be divided into two parts, the descriptive and the explanatory. A rock, for instance, is described according to its mode of occurrence, structure and mineralogical composition; then follow deductions as to the epoch at which it was formed, and the mechanism of the actions by which its particular characters have been produced. This, as a rule, marks the limit of the geologist's investigation of such a problem; seldom, far too seldom, are the conclusions submitted to the decisive test of experimental methods. This lack of the confirmatory evidence of experiment makes a large part of the literature of Geology very unsatisfactory reading, the deductions being too often either indefinite or inconclusive. In the present article we give a sketch of some of the efforts which have been made to raise Geology to the rank of an experimental science.

In the last years of the eighteenth century a controversy raged between the schools of Hutton and of Werner as to whether heat or the action of water had been the dominating influence at work in the formation of the rocks of the earth's crust. By what agency, for example, had chalk been converted into limestone or marble? How can this have been effected by heat, said the school of Werner, since heat decomposes carbonate of lime, expelling the carbonic acid? The answer to this question was furnished by the experiments of Sir James Hall, "*On the action of heat as modified by pressure.*" Chalk was heated in a gun-barrel, the end of which was firmly closed. Under these conditions, the pressure increasing as the temperature is raised, the carbonic acid is not driven off from the carbonate of lime, the change induced being not chemical but physical, the powdery non-coherent chalk being converted into a compact crystalline mass, having all the characters of limestone, or of marble. Hall also investigated another problem connected with the same controversy. Hutton maintained the purely igneous origin of those rocks which have characters similar to the modern lavas. It had, however, been noticed that if a piece of a crystalline rock were melted in a crucible it was not reproduced on cooling, but that an uniform glassy mass was formed. By a judicious combination of the methods of observation and of experiment, Hall obtained important evidence as to the conditions of crystallisation of rocks. He observed during eruptions of lava that a great part of the crystallisation of the constituent minerals took place slowly, and by degrees, during the gradual cooling of the mass of molten rock. Basing a method on this observation, he melted various rocks in graphite crucibles, and maintained the materials in a state of fusion for a long time, taking care that the temperature should be somewhat above that necessary to melt the glassy mass. Crystals gradually formed, and a crystalline rock was reproduced, of which the melting point was higher than that of the glass formed in previous experiments, where the cooling had been rapid. Similar experiments were conducted about the same time (1804) by Gregory Watt. They were on a larger scale, a reverberatory furnace being employed in place of a crucible. The molten material was only allowed to cool with extreme slowness. From time to time samples were withdrawn and examined after solidification. Those in which the annealing process had continued longest were the most perfectly crystalline, and possessed the highest specific gravity, just as a natural crystalline rock, such as granite, is denser than a glassy rock (*e.g.* obsidian) of the same chemical composition. These early experiments elucidated several important points with regard to the processes which have taken place in the formation of the eruptive rocks. The products obtained were, however, at most very imperfect reproductions of the natural rocks, and the methods for the determination of mineral species were at that time too rough to allow of the identification of the small and imperfect crystals obtained. Before the date (1866) of the next important experimental research on the formation of rocks by igneous fusion, the application of the microscope in petrological work had effected a revolution in this respect. A slice of rock, so thin as to be transparent, reveals to the microscope the outline, and even the internal structure, of the minute crystals which form its groundwork or *base*. The crystal of each mineral species shows its characteristics of form, the particular angles at which its faces are inclined to one another, and the lines developed in the process of grinding the thin section which indicate the directions of cleavage. Not less important in identification are the optical characters which determine the tints which different parts of the field of view assume according as the polarised light passes through the plate of one or other of the minerals of which the rock is composed. The refinements of optical analysis enable the identification of the species to be made with certainty even in crystals of microscopic size. At the date to which we have referred, M. Daubrée published his experi-

ments on the reproduction of the rocks of a certain class of meteorites. The meteorites being melted and kept for some time in the liquid condition, the constituent minerals began to crystallise out, and finally, after slow cooling, a rock was produced having the same constituent minerals as the original meteorite. Almost the only difference between the meteorites and the artificial products was the absence in the latter of that *brecciated* structure which frequently characterises an eruptive rock which has undergone violent mechanical strains. By the employment of the modern refinements of microscopic and of chemical analysis, Daubrée was able to establish the absolute identity of the minerals contained in his artificial products with those of the meteorites. The class of meteorites for which the method of reproduction was found successful were those containing the smallest proportion of combined silica, characterised by the presence of olivine and augite and by the absence of the feldspars. Except for the presence of metallic iron, the mineral composition of these meteorites is very similar to that of what are termed the ultra-basic rocks, *i.e.*, those the analysis of which shows the smallest proportion of silica. Many basalts and other lavas come under the category of ultra-basic or basic rocks. Observational evidence appeared, however, to favour the view that these rocks had not been produced by the purely igneous method employed by Daubrée, but that the action of water had played an important part in their formation.

It was in 1878 that MM. Fouqué and Lévy commenced the celebrated research in which they showed that the more basic eruptive rocks can be reproduced in every detail of mineral composition and structure by the action of heat alone without invoking the aid of pressure, or the intervention of water or any other substance not forming a constituent of the rock. To appreciate the details of their method it is necessary to make clear the guiding data which were furnished by the study of the minute structure of rocks. Some eruptive rocks are entirely composed of an aggregate of perfectly crystallised minerals. One or more of the constituents (in granite, the quartz) may not show crystalline faces; they have presumably solidified last and have been compelled to mould themselves round the crystals already formed, but their structure is completely crystalline, as is shown by their action on polarised light. Other rocks differ from the *holocrystalline* in that the crystallised minerals are imbedded in a vitreous or glassy matrix which scarcely affects polarised light. These rocks are classed, from the character of the ground mass, as glassy rocks. The most common structure of eruptive rocks is that of the third class, of which the ground mass has begun to crystallise before solidification, but the crystallisation has only gone as far as the production of *microliths*. These are crystals of small size, most frequently microscopic, which are so far developed that the determination of their species is readily effected. They are seen to be grouped round the larger crystals of the rock in a manner plainly indicating their later formation. It appears reasonable to suppose that the microliths are formed during and after the welling up of the rock, whilst the formation of the large crystals may be referred to a previous epoch before the disturbance of the fluid mass from its subterranean position, when a condition of calm fusion favoured their growth and development. The temperature at which they were produced must be supposed to be higher than in the case of the microliths. Between these two epochs of crystallisation comes the eruption, during which the older crystals may be rounded, worn, or broken by shock. Hall had shown that to obtain a crystalline structure instead of a glassy mass, it was necessary to keep the material at a temperature slightly above that of the melting point of the glass; but if, as appeared probable, the minerals of the different epochs of crystallisation did not possess the same degree of fusibility, it would be necessary in order to reproduce this association of minerals to maintain the materials at a series of temperatures successively decreasing. The result of the final operation might be expected to be the solidification of a mass of microliths of the more fusible minerals cementing together the larger crystals already formed. Such was the method employed by Fouqué and Lévy, and the result was in complete accordance with their expectations. As an example of their work, we will describe the reproduction of a basalt precisely similar in character to certain basalts found in the Department of Auvergne. A mixture of substances prepared in the laboratory of the same chemical composition as the rock was placed in a platinum crucible, which was maintained at a white heat for forty-eight hours. A sample taken out at the end of this time, and allowed to cool rapidly, showed on solidifying crystals of olivine imbedded in a brown coloured glassy matrix. At the end of the first forty-eight hours the position of the crucible in the furnace was changed so that the temperature was lowered to that corresponding to a bright red heat, at which it was kept for a second period of forty-eight hours. The product obtained at the end of this time showed the crystals of olivine as before, but imbedded not in a glass but in a matrix composed of microliths of augite and of soda-lime feldspar. Among the other rocks reproduced was a leucite-lava, the crystals of leucite having rounded angles just as in the natural rock, showing that this peculiarity is not necessarily due, as had been supposed, to the effects of disturbance after the first epoch of crystallisation. The rocks produced by the methods we have described are of the same character as those formed in the volcanic eruptions of the present time, which belong to the class of the more basic rocks. The more siliceous rocks, such as granite, which contain free silica in the form of quartz, do not appear to be formed under the conditions obtaining in the eruptive processes which geologists have been able to observe in actual operation. When the materials of the *acid* rocks are subjected to the processes above described, the minerals which crystallise out are not those of the original rock, but are of different crystalline form, even when they have the same chemical composition. The excess of silica remains in the uncombined state, but has characters resembling those of the variety known as tridymite rather than those of quartz. The acid rocks and their characteristic minerals (as quartz potash-feldspar and soda-feldspar) have doubtless been formed by processes radically different from that of simple fusion. The minerals above mentioned have been reproduced by the reaction of suitable materials in the presence of water, at a high temperature and pressure. Hitherto it has not been found possible to produce the compacted association of these minerals which constitutes an acid rock. Sufficient data have, however, been obtained to justify the belief that at no distant date the problem of the mode of formation of this class of rocks will be solved by the experimental method.

One of the most important contributions to experimental geology during recent years, is the discovery of Spring, that pressure is capable of inducing chemical change independently of its effect in raising the temperature of bodies. This discovery has a direct bearing on the phenomena of *metamorphism*, or the bodily conversion of sedimentary rocks into others of a completely different character. Spring has shown, that by the application of great pressure, chemical combination is induced, in cases where the compound occupies a smaller volume than the components, and conversely that a decomposition is brought

about by pressure, when the volume of the bodies formed by decomposition is less than that of the compound. Briefly, pressure brings about such chemical changes as are accompanied by a contraction. The apparatus employed in these experiments consisted of a small steel chamber, in which the substances were placed, furnished with a piston worked by a powerful lever, provided at the end with a heavy weight. If the piston were forced down rapidly the substances would be heated, and it would be impossible to discriminate between the changes due to rise in temperature and those due to increased pressure. In Spring's apparatus the lever is lowered very gradually, its descent being regulated by a finely cut screw. The steel chamber is surrounded by water, in which is placed a delicate thermometer, and the descent of the piston is operated so gradually that there is practically no rise of temperature. These experiments afforded the first example of the direct conversion of mechanical work into chemical energy.

As a last example of the application of experimental methods in Geology, we will deal with some of the problems presented by mineral veins. The cracks and openings by which rocks are traversed are in some cases unfilled, in others they contain *débris* of the rock itself, and lastly, they are sometimes found filled with foreign minerals, and are then known as mineral veins. Most of the fine well-crystallised minerals which adorn museum collections come from mineral veins, or from cavities in rocks, known as "geodes." Tin veins, for instance, contain the oxide of tin, cassiterite, in large well-formed crystals. Others contain oxide of iron, also well crystallised; and another class contain the metallic sulphides, such as galena, the common lead ore found in Derbyshire and elsewhere. The processes by which these minerals have accumulated in the veins, and the mode in which their crystallisation was induced, long remained a mystery. In studying the characters of tin veins, Daubrée was struck by the constant presence of minerals, such as apatite, topaz and tourmaline, which contain the elements chlorine and fluorine. It is known that the chloride and fluoride of tin are volatile, and that these compounds are decomposed by water, the hydrogen of the water forming hydrochloric or hydrofluoric acid gas and the oxygen combining with the metal. Experiment showed that if the vapour of water be brought in contact with that of chloride of tin at a fairly high temperature the oxide of the metal is formed in crystals, having all the characters of the mineral cassiterite. Later, Sainte-Claire Deville showed that by passing hydrochloric acid gas over strongly heated oxide of tin, the chloride of the metal was formed, and steam. These two gases are carried on by the current of hydrochloric acid gas, and in a somewhat cooler part of the apparatus react again upon one another, re-forming hydrochloric acid, and depositing the oxide of tin in the crystalline form. Hydrofluoric acid and other re-agents which have been found to act in a similar manner have been termed *mineralisateurs*. They are capable of effecting the transport of non-volatile substances, such as oxide of tin, depositing them in the crystalline form, and, their work done, they leave no trace of their former presence except in the combination of their more active elements with constituents of the surrounding rock or of certain minerals of the vein, the gauque minerals as they are termed. One of the commonest of the gauque minerals is calcite, and by passing the vapour of chloride of phosphorus over heated calcite, Daubrée found that apatite is formed, a mineral which, as has been said, is characteristic of tin veins. In the formation of the metallic sulphides, sulphuretted hydrogen has played the part of *mineralisateur*. In some cases, no doubt, the mineralising action is effected by the vapour of the active substance ascending from the heated interior; in other cases, as in the neighbourhood of the great Compstock Lode, the substances are in solution, subterranean streams saturated with sulphuretted hydrogen and other powerful solvents serving to extract the metallic compounds from the rocks in which they are present in small quantities and concentrating them in the veins. By such processes metallic ores are collected in the rock veins, which thus become the great storehouses of mineral wealth.

FLYING ANIMALS.

By R. Lydekker, B.A.Cantab.

(*Continued from page* 115.)

The wing of a Bird, although constructed on the same fundamental plan as that of a Pterodactyle, differs altogether in the manner in which the bones corresponding to those of the human hand have been modified for the purposes of flight. In the wing of a Bird only three fingers are represented at all, and these probably correspond to the thumb, index, and middle fingers of the human hand. Moreover, while the thumb is only represented by a small splint of bone, which carries the so-called "bastard wing," the bones of the index finger are flattened, and much larger than those of the third one, with which, in living birds, they are more or less closely united. This finger, therefore, forms the chief part of the extremity of the wing or pinion; but, instead of its bones being much longer than those of the arm and fore-arm put together, as is the case with the elongated outer finger (4th or 5th, as the case may be) of the Pterodactyle, it is much shorter, and, indeed, is frequently shorter than either the bone of the upper arm or those of the fore-arm alone. The finger, therefore, is the least important part of a Bird's wing, whereas the outer finger is by far the most important element in that of a Pterodactyle.

It would involve a large amount of detail to give a full description of the arrangement of the feathers of a bird's wing; and it must accordingly suffice to say that the large flight-feathers carried by the pinion are known as the *primaries*, while those attached to the larger bone of the fore-arm are termed *secondaries*; the smaller feathers which overlie these being designated as the *wing-coverts*. In all living birds, as we have said, the bones representing the fingers are flattened, and those of the index and third fingers more or less united together. In the *Archæopteryx*, which is the oldest known bird and a contemporary of the Pterodactyles of the Lithographic Limestones of Bohemia, all the three fingers were, however, perfectly separate from one another, and each ended in a claw; while the index was not greatly larger than the other two. We have, therefore, in this bird a decided approach to reptiles; from which class it is considered that birds were originally derived.

In addition to their wings we must not omit to mention that the tails of birds form an important aid in flight, when they act as a kind of rudder. In all living birds the bones of the tail are extremely few in number, and the large tail-feathers all take origin close together, and are generally spread out in a more or less fan-like manner. Our old friend the Archæopteryx had, however, a very long lizard-like tail, with a pair of feathers arising from each of its numerous joints, after the manner of the feathers on an arrow. It will, however, be readily imagined that such a long unwieldy tail was by no means calculated to act as an efficient and compact rudder; and the shortened tails of modern birds appear, therefore, to

be a decided improvement on the early type. It seems, indeed, that in all groups of Vertebrates capable of true flight a long tail has been found disadvantageous, since among the Pterodactyles the more specialised kinds found in Europe had discarded the long tail of the species represented in Fig. 8; and the same holds good with regard to the large toothless kinds found in the cretaceous rocks of the United States. Again, the most specialised, or insectivorous Bats are remarkable for the shortness of their tails. From the relative shortness of its wings, coupled with the long unwieldy tail, it is probable that the Archæopteryx was but a poor flyer, and was, perhaps, altogether incapable of making the long-sustained flights of our modern birds, though it must undoubtedly have been a true flyer.

Birds vary greatly in the relative proportions of the component bones of the wing, so that among the strongest flyers we find that whereas in the giant Albatross of the tropical seas the bones of both the upper and fore-arm are enormously elongated, in the Swift that of the upper arm is so shortened and thickened as to be scarcely recognisable. The form and arrangement of the flight-feathers are, however, of still greater importance in modifying the shape of the wing, but the reader desirous of information on this subject must consult one of the numerous works on the structure of birds.

Coming now to the highest class of animals, the Mammals, we shall find that while true flight is only possessed by the whole of the members of a single order, spurious flight occurs among certain members of three widely distinct orders; and it is curious to notice the remarkable external similarity between some of these animals possessing the power of spurious flight, while they are structurally so different from one another.

Commencing with spurious flight, the first Mammals we have to mention are the Flying Phalangers of Australia, which belong to the great order of Pouched or Marsupial Mammals, described in a previous number of Knowledge, and are closely allied to the so-called Opossums of the colonists. There are several genera of these curious and beautiful creatures, distinguished from one another by the character of the skull and the shape of the parachute, which may be either very broad or very narrow. This parachute consists of an expansion of the skin of the sides of the body, extending from the wrist of the fore-leg to the ankle of the hind-leg, with a smaller development between the neck and the front of the fore-leg. The Flying Phalangers are strictly nocturnal in their habits, and are able to take enormous flying leaps from tree to tree, during which they descend in the first part of their course, but acquire a slightly upward direction before they alight.

It is not till we come to the order of Rodents, or those Mammals which, like Hares, Rats, and Beavers, are provided with a pair of chisel-like gnawing-teeth in the front of each jaw, that we again meet with Mammals having the power of spurious flight. Among the most curious of these are the so-called Anomalures of Africa, which are small Rodents nearly related to the Squirrels. Here we find the parachute connecting both pairs of limbs together, as in the Flying Phalangers, but with the additional peculiarity that there is a spike-like rod of cartilage projecting from the elbow, which, by acting in the manner of a yard-arm, allows the width of the expansion to be greater than could otherwise be the case. This rod, together with the presence of a series of scales along the sides of the base of the tail—from which the creatures take their name—serves to distinguish the Anomalures from the Flying Squirrels. Of the latter there are three genera, mostly found in the oriental region, although a few species range into North America and Europe. These creatures exactly resemble ordinary Squirrels in general appearance and habits, with the exception of having a parachute connecting the front with the hind limbs, after the manner of the Flying Phalangers. In some species an additional membrane connects the root of the tail with the thigh, but this is wanting in others. The flight of the Flying Squirrels is precisely like that of the Flying Phalangers; and if the two were to be found together, it would be quite impossible to distinguish the one from the other during flight. Flying Squirrels, however, utter a sharp, squeaking cry during their flight, while the Flying Phalangers appear to be silent. Ordinary Squirrels, as we all know, are capable of taking long leaps from bough to bough, and in the Flying Squirrel it is merely an excess of this power which, owing to the development of the parachute, assumes the character of flight. A precisely similar connection obtains between the ordinary Phalangers and the Flying Phalangers. There are a large number of species of Flying Squirrels, which are mostly of comparatively small size, although one species, from the north-west of Kashmir, is as large as a rabbit. Although their cries may frequently be heard at night in the districts which they inhabit, Flying Squirrels are but seldom seen. Their flight may be extended to a distance of twenty-five or thirty yards.

The Flying Lemurs, of the Malay Peninsula and the Philippines, present a type of Mammal in which the faculty of spurious flight has attained its maximum of development. These animals come nearest, in general structure, to the so-called Insectivorous Mammals, such as the Mole, Shrew, and Hedgehog, and are, therefore, usually regarded as forming an aberrant group of that order. In them not only are the fore and hind limbs of either side connected together by an expansion of the skin of the sides to form a parachute, but the expansion of the skin also extends backwards between the hind legs, which it connects with the long tail completely up to its tip. Moreover, although the fingers and toes are only of the ordinary length, yet they also are connected by a membrane, in the manner of the webbed foot of a duck. At night, during which time they become active, the Flying Lemurs will take flights of upwards of seventy yards in length, and thus far outrival the Flying Squirrels and Phalangers in this respect. Bats, as we shall notice shortly, are known to be closely allied to the Insectivores, and the Flying Lemur seems to show us how an ordinary Insectivore may have become gradually modified into a Bat; for it would only require the elongation of the fingers and a somewhat greater development of the parachute to transform the Flying Lemur into a creature exceedingly like a Bat.

Bats, which are familiar to all of us, are the only Mammals endued with the power of true flight; and although they are evidently related, as shown, among other features, by the structure of their teeth, to the Insectivores, yet they are so different as to be entitled to rank as a separate order by themselves. In being the only truly flying Mammals they hold, as has been well observed, a position in the class precisely analogous to that occupied among the Reptiles by the Pterodactyles. That they have, however, no sort of connection with the latter group is perfectly evident from the structure of the fore-limb, or wing, which we now proceed to explain.

The wing of a Bat is composed of a thin naked membrane supported by a great extension of the bones of the fore-limb; this membrane being continued backwards to connect the hind-legs with the whole length of the tail.

In the fore-limb, of which the skeleton is represented in Fig. 4, the bones of both the arm and fore-arm are

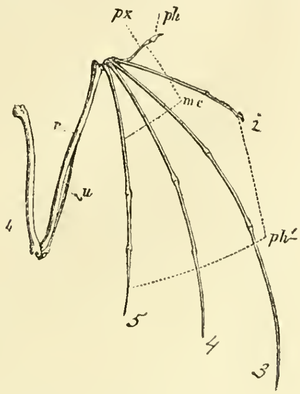


Fig. 3.—The bones of the right fore-limb of a Bat, seen from above. *h.*, bone of arm; *r.u.*, bones of fore-arm; *p.x.*, thumb; *ph.*, claw of thumb; *m.c.*, metacarpus; *ph*¹, 2nd, 3rd, 4th, and 5th fingers.

relatively slender and considerably more elongated than usual. The thumb remains comparatively small, and ends in a claw; but all the other fingers—more especially the third or middle one—are enormously elongated, so that the third, fourth, and fifth, which have no claws at the end, are absolutely longer than either the fore-arm or the arm. Between these elongated spider-like fingers the wing-membrane is stretched, the whole structure permitting of the wing being folded, when at rest, in the manner familiar to all. A comparison of Fig. 3 with Fig. 2, or, still better, with the figure of the skeleton of a Pterodactyle, given in the article on Flying Dragons, will show how essentially the wing of a Bat differs from that of a Pterodactyle. As we have said, the single finger supporting the wing-membrane of a Pterodactyle corresponds either with the one marked 4 or that marked 5 in Fig. 4 (probably the latter), and it may therefore be said that while a Pterodactyle flies with one finger, a Bat flies with its whole hand. Equally marked is the difference between the wing of a Bat and that of a Bird; the latter having only the first three fingers of the Bat's wing developed, and all of these being strangely modified from the ordinary form, while the chief elongation has taken place in the bones of the arm and fore-arm, instead of in those of the fingers, and flight is effected by the aid of feathers instead of by a membrane.

This completes our survey of the various modes of flight obtaining in the animal kingdom. In it we have indicated the difference between spurious and true flight, have shown how the former is but an extreme development of the long leaps taken by arboreal animals, and have suggested how it may have gradually passed onwards into true flight. We have also seen how the wings of the Invertebrate animals differ *in toto* from those of the Vertebrates; while among the Vertebrates true flight has been independently developed in three distinct groups—Pterodactyles, Birds, and Bats—on totally different structural lines; the latter instance thus affording us an excellent example of the way in which different groups of animals may be variously modified to occupy the same position in the realm of nature. The supersession of the Pterodactyles by the Birds as the lords of the air is in accordance with what we have observed elsewhere, namely, the replacement, with the advance of time, of a lower by a higher type of organization. The Bats, indeed, which belong to the highest class of animals, appear to have been the latest in which the power of flight has been developed; but since most of them are of comparatively small size, and of more or less completely crepuscular and nocturnal habits, they have never entered seriously into competition with the Birds, so that both groups are found existing side by side in full development.

THE COMPANION TO α URSÆ MAJORIS (β 1077).

By S. W. Burnham.

THE close companion to α Ursæ Majoris, which was found with the 36-inch refractor in the early part of 1889, has now been measured each year since that time. These observations show clearly that the companion is moving round the principal star in a retrograde direction, and that the two form a physical system. The proper motion of α is not large (0·144″ in the direction of 240·5°), but it is sufficient to show in the measures of so close a pair, even in the two years covered by the observations.

The following are the measures down to this time:—

1889·19	326·1°	0·91″	β 4n.
1890·26	320·1°	0·87″	β 4n.
1891·30	316·8°	0·80″	β 4n.

It is not unlikely that it may prove to be a rapid binary, and that the distance is now about maximum. In that case a more rapid change in the angle may be looked for soon. It is easily measured with the large telescope when the conditions are good, but with a distance of one-third, or even one-half that given in the measures, it would probably be a severe test for the 36-inch. So far as I know it has not been seen anywhere else, though some of the large refractors ought to show it. I hope to measure it regularly each year for some time to come.

Lick Observatory, *June 2nd.*

ASTRONOMY AS TAUGHT BY ACADEMY PICTURES.

To the Editor of Knowledge.

Sir,—Will you allow me to say a few words in reply to your notice of my picture of Jeremiah Horrocks in the Royal Academy. Three points are there singled out for animadversion. First you say that I have drawn Venus too small, "the black disc representing Venus should be larger." You do not say how much, so the reader might infer some terrible disproportion in my delineation. May I point out that the major diameter of the Sun's disc in the composition measures one inch and three-quarters, and the minor one about half that size. The sub-division of the former into 30 will give the proportional size of Venus, this being a speck not much, if at all, larger in size than that which I have delineated, keeping in mind the fact that this is a foreshortened perspective view, and not one seen full front, as it would be in a circular diagram. You add that the place of Venus upon the Sun's disc is not quite low enough on the right hand limb. As a fact I have copied it from the sketch to be found in the text of the "Venus in sole visa," left by Horrocks and published by Hevelius.

You state "there is no authority for the curious equatorial mounting" which I have drawn, "or for the attachment of the sun-screen to the instrument by a rod. In fact, we know that such a mounting could not have been used." My authority is the illustration to be found—rod, screen, and all—in the work published by Padre Scheiner in 1626, called "Rosa Ursina," giving full warrant for its use in Horrocks' time. The telescope is there seen fastened by strings, enabling him to take it off and place it, if need were, as suggested by you, but not necessarily precluding its use in any other manner that might occur to the astronomer who was so full of resources. The clouds, which only dispersed at the late hour of his observation, enabled him to take very deliberate precautions beforehand for his final survey. You say the tube was evidently home made; whether that was the case or not, it was of the best kind, as he states, "The telescope which I employed on this occasion is much more accurate than those generally used," leading to the belief that he probably had more than one of those instruments in his possession. He probably set the telescope to the position it would occupy when he came out of church, as if it had been driven by clock work.

To your final objection as to the omission of the cassock, as part of his dress, I think I must plead to its being done purposely, as I thought its ample folds would have interfered seriously with the movements necessary during his observation in a small room full of the accessories necessary for the fulfilment of his purpose.

Yours very truly,
Eyre Crowe, A.R.A.

[To follow Mr. Eyre Crowe, I would gladly exercise a little poetic imagination, and suppose that Horrocks knew the time within two minutes when he would be able to finish his service and get to his rooms. The Sun appears to move by reason of the earth's daily rotation through its own diameter in about two minutes. Consequently, if Horrocks had had modern facilities for timing his clocks and accurately setting his telescope, he might have hoped to find some portion of the Sun's disc thrown on the screen. But in order that he should enter the room and find the image of the Sun centrally on the screen, as Mr. Eyre Crowe depicts it, Horrocks must either have had a telescope moved by clock work, or he must have moved himself with the precision of very accurate clock work, for he must have entered the room within ten seconds of the time he had intended and calculated for. If this is Mr. Crowe's theory, why did he not give Horrocks' equatorial mounting a divided circle to enable him to set the instrument in right ascension? Scheiner's instrument, as shown in the "*Rosa Ursina*," had such a divided circle about the base of its polar axis, roughly divided it is true, but it would no doubt have enabled him to find a star or the Sun's place within a quarter of an hour.

I did not suggest that equatorial mountings were not used in Horrocks' time. They were certainly in use before telescopes were invented, as is proved by the plates in Tycho Brahe's "*Astronomiæ instauratæ mechanica*." But such an instrument would have been quite unsuited for use in Horrocks' room. It would have needed to be out in the open, or under a revolving roof, to have enabled Horrocks to watch through the whole day with it. Horrocks says that he commenced watching from sunrise, and went on at every available opportunity through the whole day. But with Mr. Eyre Crowe's mounting he would only have been able to see the Sun as it passed across the parts of the sky visible from the centre of the room through the narrow windows.

Mr. Crowe tells me that I have not said how large the disc of Venus should have been drawn. Horrocks estimated it as about a quarter of an inch in diameter, or a little more. I did not measure Mr. Crowe's picture with a divided rule, but compared the body of Venus with the size of the eye of Horrocks. The diameter of the iris of most people is about three-eighths of an inch, or a very little more. Horrocks' head is not far from the Sun's image, consequently the diameter of Venus ought to have been represented as about two-thirds of the diameter of the iris of Horrocks' eye. But Mr. Crowe represents it as a little round black spot of perhaps a fifth of the diameter of Horrocks' iris, making allowance for the fact that the whole of the iris has not been shown. The disc of Venus ought not to have been circular, but should have been elliptical, like the foreshortened disc of the Sun.

Mr. Crowe says that he has copied Hevelius's diagram, but he has not copied the scale Hevelius gives, which was so carefully drawn by Horrocks. The use of this scale occupied Horrocks' attention during the whole of the observation, and enabled him to measure the diameter of the planet, and to determine its place upon the Sun's disc. Curiously enough, Hevelius's diagram is a little inaccurate. Horrocks was careful to say that he made his divided circle six inches in diameter. Hevelius's diagram is about six and a half inches in diameter.

Mr. Crowe has also given an Artist's rendering of Scheiner's equatorial stand, especially as to the mounting of the octagonal polar axis, which could not have been turned in its bearings as it is drawn by Mr. Crowe.

I hope that my criticisms will not have the effect of deterring Mr. Crowe from again attempting an astronomical subject. I should be delighted to be of service to him if he should again enter the field.—A. C. Ranyard.]

BIRDS AND BERRIES.

By the Rev. Alex. S. Wilson, M.A., B.Sc.

(*Continued from page 53.*)

The prevailing colours of succulent fruits are red, blue, purple, orange, and black. White berries are comparatively rare. In this respect the colours of fruits differ from those of flowers. Black, though occasionally seen in violets, is rare in flowers; white, on the other hand, is common. Perhaps the explanation of this difference is to be found in the circumstance that night-blooming flowers are white to suit their nocturnal visitors; whereas, very few frugivorous birds being nocturnal in their habits, we should expect a corresponding absence of pale-coloured fruits. The latter might, however, be readily discovered by fruit-eating bats. If at any particular season we compare the colours of the fruits then ripe with the tints of the flowers in bloom at the same time, we cannot fail to remark the greater uniformity of colour among fruits. Thus the fruits of honeysuckle, wild rose, yew, and holly differ much less in colour from each other than the contemporary flowers.

Notwithstanding this, birds appear to recognise when fruit is ripe by the change of tint it shows. We have seen a rowan-tree stand for days and no birds come near, although it was covered with berries; but, directly these assumed their deep orange tinge, numerous blackbirds appeared and cleared the tree in a single day.

Nature commonly avoids the superfluous. The colour of the fruit in many instances does not extend over its entire surface, but is confined to the exposed side; the concealed portions resembling the foliage by which they

are hidden. Hence the rosy cheek of the apple, peach, &c. In the magnolia we find a remarkable arrangement. Its fruit is dry and contains but one seed. One-seeded fruits do not as a rule open, but themselves become detached from the mother plant, and are dispersed. Magnolia is, however, an exception. Its one-seeded fruit which remains on the branch opens suddenly, and the seed is jerked out; but, instead of falling to the ground, the seed is retained by its long string-like stalk or funiculus, and hangs down outside the capsule. The external portion of the seed is succulent and coloured, resembling that of the pomegranate, and there can therefore be no doubt that the object of thus hanging out the seed is to expose it in such a way that it will readily catch the eye of some bird.

A peculiarity noticed in the raspberry and some others is deserving of mention. The fruit, partially hidden by the leaves, can be seen more readily by a person standing at some distance from the bush than when close beside it. The intention seems to be to discourage birds from settling on the plant and devouring its fruits in quantity on the spot. This peculiarity compels a bird to make more numerous journeys, and secures wider distribution. Further, when the bird is under the necessity of flying to a neighbouring tree to consume the fruit it has got, or to make a survey in search of more, the seeds stand a better chance of being delivered in localities favourable to their development—that is, in situations where birds are in the habit of perching, such as thickets and shaded plantations corresponding to the habitat of the rasp and similar plants. Wind-carried seeds would have very little chance of penetrating these sheltered situations unless of minute size. But the smaller the size of a seed the more scanty is the stock of nourishment it can afford for the development of the embryo during germination. This, to plants which affect a shady habitat, would be a decided disadvantage, and therefore the mass of the seed cannot with safety be reduced below a certain limit.

Succulent coloured fruits are very common in the order Rosaceæ, to which most of our cultivated fruit-trees belong. The apple, pear, medlar, quince, peach, plum, cherry, rasp, and strawberry are members of this order. It is somewhat remarkable that while the fruits of Rosaceæ are thus highly specialised the flowers should belong to a comparatively simple type, having, as a rule, separate petals and exposed honey. In some genera, such as *Alchemilla* and *Poterium*, the flowers appear to have degenerated into the apetalous condition.

Glancing over the list of plants which produce succulent fruits, we observe that these are either trees or shrubs, herbaceous species being almost unrepresented. The same rule evidently applies to fruits which, as we have seen, holds good in the case of flowers requiring the assistance of birds. Fruits of this description produced too near the ground would not only escape the notice of birds but would present a strong temptation to many terrestrial creatures, and attract a host of enemies in no way fitted to help in dissemination. Of this we have convincing evidence in the frequency with which cultivated strawberries are devoured by snails. Like large mellifluous flowers, fruits adapted to birds require to be placed at some distance from the ground, beyond the reach of snails, larvæ, ants, rodents and larger quadrupeds. The prickles and hairs on the stalks and outsides of many flowers are believed to prevent small creeping insects from reaching the nectar. Many of these structures may, however, render more important service in defending the fruit; the prickles of the rasp and bramble would appear to be of use in protecting the fruit quite as much as the flowers and foliage.

Birds in eating succulent fruits may either reject the stones and seeds, or these may be swallowed and pass through the intestines of the bird without losing their germinating power. This ordeal would even seem to benefit some seeds by facilitating their germination. It has at least been asserted, on reliable authority, that nutmegs which are swallowed by pigeons for the sake of the mace, thrive much better if dropped by the birds than when planted by man. Succulent fruits commonly have seeds so hard that they resist the action of the mandibles, gizzard, and stomach of most birds. In drupaceous fruits the seed itself is not hard, but it is enclosed for protection in a woody endocarp or stone. The pomegranate has the testa or outer layer of the seed soft, but the central core is woody; in any case the part ultimately dispersed by the birds is hard. This, in the date and grape, is the seed; in the strawberry and fig, the fruit or achene; in the cherry, rasp and bramble, the endocarp; and in the gooseberry and currant, the indurated core of the seed. Indurated seeds and fruits are not, however, confined to plants which employ birds in the work of dissemination. Mice, squirrels, and other small rodents, consume large numbers of seeds, and where this danger has to be met it is of the highest importance to a plant to possess hard seeds. This is in all probability the explanation of the remarkably hard nutlets of some of the Labiatæ and Boraginaceæ, and of the stone-like seeds called Brazil nuts. The flinty cocci of *Lithospermum* are calculated to give even a rodent the toothache. The glassy grains of *Coix lacryma*, known as Job's tears and used as beads, and the horny albumen of the palm *Phytelephas macrocarpa*, which furnishes vegetable ivory, are marked examples of this excessive hardness.

By accidentally dropping nuts, monkeys and squirrels may occasionally assist in dispersion; but it may be doubted whether this occasional service is a sufficient compensation for the quantities they consume. The nuts themselves, at least, cannot be said to possess any special provision for this mode of dispersion. The strong beaks of the parrot tribe, on the other hand, are well adapted for breaking open hard-shelled fruits of this description.

A disagreeable taste will prevent a seed being eaten by animals or swallowed along with the sweet pulp of the fruit. Such is apparently the meaning of the bitterness of the orange seeds, of one variety of almond, and of the fresh spermoderm of the walnut. *Cocculus indicus*, sometimes used to give bitterness to malt liquors, is the fruit of a plant belonging to the Menispermaceæ. The seeds of fox-glove and mullein are bitter, and those of the upas tree intensely so. In other cases the seed has a hot, pungent taste, as in the mustard and other crucifers. Pepper is obtained from the fruits of various orders: black pepper from *Piper nigrum* (Piperaceæ); Jamaica pepper from *Eugenia pimenta*, a plant of the myrtle family; Cayenne pepper, chillies, bird-pepper and cardamons from various members of the Solanaceæ. From *Nigella sativa* (Ranunculaceæ), *Tasmannia aromatica* (Magnoliaceæ), *Xylopia aromatica* (Anonaceæ), from the Elatinaceæ, or water-peppers, some of the Verbenas, the Polygonaceæ (*Polygonum hydropiper*), and from some plants of the ginger order, pungent or peppery seeds are obtained.

The fruits of the guelder rose, honeysuckle, ivy, dog-mercury, lobelia, and of some of the fox-glove order possess emetic properties, so that in the event of the seeds being swallowed there is a possibility of their being vomited up again. The robin eats the berries of honeysuckle, but vomits them afterwards. The fig and tamarind are examples of laxative fruits, a quality shared to a greater or less degree by most of the succulent class. Many, indeed, are powerful purgatives, such as the colocynth (*Citrullus*

Colocynthis) (Cucurbitaceæ), the jalap (*Ipomœa purga*) (Convolvulaceæ), *Euphorbia Lathyris*, the croton-oil plant (*Croton Tiglium*), the castor-oil plant (*Ricinus communis*), the physic nut (*Jatropha Curcas*) (Euphorbiaceæ); *Rhamnus catharticus*, *Bromus catharticus*, *B. purgans*, &c.

Emetic and purging seeds are not likely to be retained long enough in an animal's stomach to admit of their germinating power being destroyed.

Narcotic and poisonous properties are not uncommon in seeds and fruits. We have marked examples of this in *Atropa*, *Hyoscyamus*, *Andromeda*, *Strychnos*, and in some of the Apocynaceæ and Umbelliferæ. A seed that occasions the death of any animal that swallows it might be benefited by its poisonous properties if the rich soil furnished by the decaying body of its victim were necessary for its germination. But it is hardly possible that this can be the end intended in all poisonous seeds. If any plant were systematically to poison the birds on which it depended for dispersion one of two things must happen. Either this short-sighted policy would lead to the extermination of its benefactors, or the birds would gradually learn to avoid its fruits. In any case the plant would lose its means of dispersion, and place itself at such a disadvantage in the competition with other species as would in the long run lead to its own extinction. Further, it must be remembered that substances poisonous to man and certain other animals are without effect on certain others. Thus, rabbits eat the leaves, and thrushes the berries, of the deadly nightshade; strychnine is said to have no injurious effects upon monkeys. Poisonous compounds may be formed in plants and occur as accidental qualities, just like the mineral poisons of the inorganic world. It seems improbable that these poisons should be produced in fruits for the purpose of destroying the agents concerned in dispersion. If, however, this should turn out to be the case in some instances, it would after all be no more wonderful than what occurs in such insectivorous plants as Drosera and Dionœa.

Birds are known to eat many poisonous fruits with impunity. The fruits of the manchineel (*Hippomane*) contain a deadly poison, and yet certain birds in South America eat them without injury, just as happens in our own country with the scarlet berries of the honeysuckle. The active principle of castor oil is not found in any part of the seed except the embryo, and the poison in several of the Solanaceæ is said to occur only in the outer covering of the seed and not at all in the pericarp. All parts of Hyoscyamus are more or less poisonous. Its popular name of Henbane arises from the idea that it has a special fatality for hens. This is quite intelligible on the supposition of the poison being concentrated in the outer layers of the seed. On account of the trituration to which the seeds are subjected in the gizzard, they are much more likely to prove fatal to a gallinaceous fowl than to other birds with weaker stomachs.

Such considerations indicate that the use of these poisonous properties may be to prevent the fruits being eaten by animals, which would so thoroughly digest the seeds that their germinating power would be destroyed. The development of poisonous principles in connection with the fruit is probably of use also as a protection against injurious insects. These are very ready to attack fruits in all stages of growth; it is quite conceivable, therefore, that the poisons in berries are primarily intended to act as insecticides, and that later on they come to be of use in keeping away other animals capable of injuring the seeds.

When a poisonous principle first began to be developed in any particular fruit, the birds which fed on it, we should naturally suppose, would become gradually inured to the poison until it completely lost its effect. The liking of parrots for peppercorns, in all probability, is an acquired taste. Immunity from particular poisons might be acquired in the same way as we may suppose the strong mandibles of the parrot have been acquired in relation to hard-shelled fruits. Where poisoning occurs it would seem to be accidental, and should perhaps be regarded as arising from imperfect instincts, or as the inevitable concomitant of a transition stage in development towards more perfect adaptation. On the same principle we should also be disposed to explain the case of those Aroids whose flowers, according to Delpino, poison the snails on which they depend for fertilisation.

(*To be continued.*)

Notices of Books.

Telescope Work for Starlight Evenings. By WILLIAM F. DENNING, F.R.A.S. (London, 1891, Taylor & Francis.) Mr. Denning is so well known as a patient observer of meteors and of comets, that a work from him on observational astronomy will be looked upon with special interest. The plan of the book is somewhat on the lines of the late Mr. Webb's *Celestial Objects for Common Telescopes*; though it does not profess to compete with it in the detailed description of the moon or of stellar objects. One naturally turns first of all to Mr. Denning's chapter on meteors and meteoric observations, which contains some striking pictures of detonating meteors, and of double and curved meteor tracks. The meteor masses which enter the air are occasionally so irregular in shape that the resistance of the atmosphere as they pass quickly through it drives them out of their original course. Mr. Denning says that several outbursts of light are often noted, and sometimes a curious halting motion (which must of course be an optical illusion) has been noticed. He states that he has occasionally remarked a succession of brilliant flashes given by one fireball. These flashes, though sometimes of startling intensity, are somewhat different from the transient vividness of lightning, they come more softly, and Mr. Denning says that they remind him of moonlight breaking suddenly through the clear intervals in passing clouds. Great differences are noted in the velocity of meteors; some move very slowly, while others shoot quickly across the sky. These differences are caused by the astronomical conditions affecting the position of the meteor-orbit relatively to the motion of the earth. Thus the meteors of November 13th move with great velocity (44 miles per second), because they come from the part of the heavens towards which the earth is moving with a speed of $18\frac{1}{2}$ miles per second, while the meteors themselves are moving in nearly a contrary direction with a velocity of 26 miles a second. But in the case of the meteors belonging to the shower of November 27th, the meteors catch up the earth from behind; their relative motion is therefore extremely slow, being only about 10 miles a second. On November 12th, 1799, Humboldt at Cumana, in South America, saw "thousands of bolides and falling stars succeed each other during four hours." On November 12th, 1833, the shower recurred, and was witnessed with magnificent effect in America. It was first noted during this shower that the meteor tracks all seemed to radiate from a point in the heavens; subsequently Heis in Germany, Schmidt at Bonn and Athens, Mr. R. P. Greg and Prof. Alex. Herschel in England, by

continued observations discovered many other radiant points in the heavens from which the meteors which fall at other times of the year appear to radiate. Mr. Denning has most systematically extended the work, until now more than a thousand of such radiant regions in the heavens are known.

Optical Projection, a treatise on the use of the Lantern. By Lewis Wright (Longman, Green, & Co.) The lantern is becoming more and more widely used by teachers and lecturers, as it enables them to throw upon the screen enlarged images of physical phenomena, and to perform many experiments in the presence of large audiences which formerly could only with difficulty be exhibited to two or three at a time. But one still frequently sees demonstrators who never half develop the powers of their apparatus solely for want of duly considering its optical properties. This does not apply only to itinerant lecturers, but to polarization and other physical phenomena projected with the most elaborate electric-light apparatus at places which may be considered the very headquarters of scientific exposition ; experiments are frequently shown in a manner which gives inferior results to those which may be obtained with only oxy-hydrogen illumination. Such a book as Mr. Lewis Wright has given us will therefore be widely welcomed. It deals not only with the optics of the lantern, but with all sorts of lantern accessories, screens, slides, the lime light, the preparation of gases, &c. Several chapters are devoted to descriptions of experiments suitable for projection on the screen, many of which are ingeniously contrived. Mr. Lewis Wright has had large experience in such work, and has for years made it a special hobby. He was already favourably known to us by his excellent text-book on "Light and Experimental Optics," and the present work exhibits equal resource and ingenuity. In projecting the apparatus necessary for experiments, as well as pictures upon the screen, it is not as easy as might at first sight be imagined to arrange for an equal illumination of the field, and that as many rays as possible may be made to fall upon the slide or object, and also to pass through the projecting lens. Mr. Wright has been especially happy in contriving means to this end, suitable for very various classes of experiments, and different degrees of magnification. He states that the preparation of his book was suggested to him by Mr. Herbert C. Newton, with whom he has spent much time in contriving and testing scientific optical apparatus for the use of colleges and public institutions, and the work is in some senses a joint production, Mr. Newton's firm having made this branch of optical manufacture a speciality, have been enabled to offer Mr. Wright special facilities for experiment, and the result is eminently satisfactory.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

THE BRILLIANCY OF DOUBLE STARS.

To the Editor of Knowledge.

Sir,—Mr. Maunder falls into a mistake in supposing that my formula in *The Observatory*, Vol. X., gives the "mass-brightness" or "candle-power per ton" of a binary star. The proper expression would be "density-brightness," not "mass-brightness," *i.e.*, the relative illumination per unit of surface on the assumption that the stars were, in all cases, globes of equal density. This correction, I think, renders Mr. Maunder's figures rather more favourable to his conclusion, but the error is worth correcting as it occurs in Professor Young's well-known text book, though it will no doubt be rectified in the next edition. According to Mr. Maunder's table, only one Sirian star has a density-brightness lower than the average for Solar stars, while in no case does the density-brightness of a Solar star rise to the average for the Sirian class. I may notice that my figures in *The Observatory* for the two stars λ and τ Ophiuchi were vitiated by an error in the computation. This has been corrected by Mr. Gore.

Dublin, June 6th. W. H. S. Monck.

Reply of Mr. Maunder.

I am obliged to Mr. Monck for his correction, which I had myself perceived the necessity for almost immediately after I saw my article in type. It is curious how easily one can make and pass over so obvious an error, which looks "gross as a mountain" when the attention is called to it.

My mistake arose from a too natural interpretation of Prof. Young's graphic but misleading expression of "candle-power per ton," which caught my fancy and which I followed up without examination. The process Mr. Monck gave in *The Observatory*, and which Mr. Gore and Prof. Young have adopted from him, gives us the relative brightness per unit of surface, assuming that the two binaries have the same density. As Mr. Monck says, my mistake, however inexcusable, does not vitiate my conclusions ; rather the other way. Assuming that the illumination per unit of surface is the same for all stars, and computing the relative density, Mr. Monck's formula gives the average Solar star as fourteen times as dense as the average Sirian star. The net result, therefore, of such materials for comparison between the two types as we at present possess gives the preponderance to the Solar stars in total radiation, in size, and in density ; and the more I think over the facts we have before us—meagre enough, I admit—the more I am inclined to consider the generally received interpretation of stellar type as the result of an over hasty generalization, and to consider that difference of type of spectrum most generally indicates an actual difference of constitution.

E. W. Maunder.

PERPETUAL CALENDARS.

To the Editor of Knowledge.

Sir,—Circular Calendars have been numerous. My brother published one fifty years ago, so far as I remember, similar to Mr. Prince's, but smaller. I bought one more than twenty years ago in Paris, a very neat little thing, on white metal, about the size of a two-franc piece, and some ten years since one was described in the *English Mechanic*, consisting of three circles, one being for centuries. The chief drawback to their use is their absence when wanted, and the trouble of referring to the printed addendum to find the Sunday Letter.

The handiest mental rule I have come across, dispensing with all reference whatever, is the following. By its use, I think the week day for any date may be much more readily found than by any circular calendar or similar means.

Rule : From half following Leap Year subtract years past. In other words, from half the next greater multiple of 4, take the remainder on dividing year by 4. Divide by 7 ; remainder is date of first Sunday in March of given

year. The year of century only must be used. For other months arrange and number them as follows :—

March	April	May	June	July
0	1‡	2	3‡	4
August	September	October	November	December
1	2‡	3	4‡	5
January	February			
2	3‡			

Add the number for the month to that found for March, plus 3 when marked thus‡, reject sevens ; remainder is date of first Sunday in given month, from which other days may be found. Note.—January and February are the last two months of preceding year ; also, that the numbers in second and fourth columns, marked ‡, are 30-day months.

The above is for present century only. For next century add 2 ; for last century reduce by 2, and generally for any century, new style, divide centuries by 4 ; twice remainder plus 3, throwing out sevens, gives number to be added.

Old style centuries : To centuries add 5, or subtract 2, and reject sevens.

Examples. 1891. Next following leap year is 92, half is 46 ; being third after leap year, deduct 3 ; divide by 7, remainder is $1=$ date of first Sunday in March. April is $1+1+3=5$; May, $1+2=3$; June, $1+3+3=7$; December, $1+5=6$; February, '92, $1+3+3=7$, &c., &c.

A.D. 1, O.S. Centuries$=0+5=5$; year$=2-1=1$; $5+1=6$, date of Sunday in March.

1815, June. Centuries$=0$; year is $8-3+3+3=11+7=18$th, a Sunday.

Yours truly,
C. Lund, Ilkley.

To the Editor of Knowledge.

Sir,—I was very pleased with, and greatly interested in, Mr. Hutchinson's article on "The Cause of Volcanic Action," which appeared in the current month's issue of Knowledge. But there is one point upon which I should feel extremely obliged if Mr. Hutchinson would give a little further information. On page 106 he says, "A much more promising explanation is that there are below the crust of the earth large masses of highly heated rock, kept solid by the enormous pressure of overlying rocks ; and when earth-movements take place within the crust, such as the upheaving of a mountain chain, taking off some of the weight, the balance of pressure is no longer maintained, and so the highly heated rock runs off in a liquid state, and finds its way to the surface, producing volcanic action." I should like to ask, am I right in assuming that the above explanation refers only to the original formation of volcanos, and if so, what is the disturbing cause in the case of Vesuvius, Etna, and other mountains, which have longer or shorter periods of quiescence, and when active are not associated (as far as I am aware) with earth-movements such as the upheaval of mountain chains ? In the theory propounded by Bischoff (who, I think, believed the centre of the earth to be in a molten state), water is the great factor as a disturbing cause. It also plays a very great part in the theory (chemical changes) propounded by Sir Humphry Davy, who held the opposite view with regard to the earth's interior. Hoping, sir, that you will kindly find a corner for this request in your next issue,

I remain, yours faithfully,
H. Christopher.

[A scientific theory which is "not proven" must necessarily leave room for some difficulties. I think it was Wellington who said the best general was the one who made the fewest mistakes. So with scientific theories—that one is the best which presents the fewest difficulties. The question raised by Mr. Christopher is not easily answered. The explanation of volcanic action referred to in my paper applies to the original formation of volcanos, and explains their association with mountain chains ; but, at the same time, I conceive that it also applies to the case of Vesuvius and other volcanos now in eruption, which do not appear to him to be associated with the upheaval of mountain chains. But in reality they are so associated. The upheaval of the mountain chain was the cause which brought them into existence, and, having once begun their activities, they go on for a long period—probably until the balance of pressure below has been restored by the creeping of heated rocky matter in that direction. Vesuvius will go on as long as such matter is slowly impelled to its neighbourhood, just as water will squirt out of an indiarubber ball as long as you squeeze it. When other earth-movements start somewhere else the movement may take place towards some other line of upheaval which at present does not exist. This does not necessarily imply the presence of molten rock below, but only of rock sufficiently heated and viscous to creep along as clay or putty would under pressure. I cannot believe that water is the disturbing cause, for it must be present in considerable quantity in all subterranean regions. Lastly, a very little disturbance of the earth's crust may suffice to alter the balance of pressure below.—H. N. Hutchinson.]

To the Editor of Knowledge.

Sir,—No doubt most of your readers have been favoured, at some period of their life, with a proof that one is equal to two. Perhaps the enclosed view of the matter may be equally convincing.

Yours faithfully,
R. Chartres.

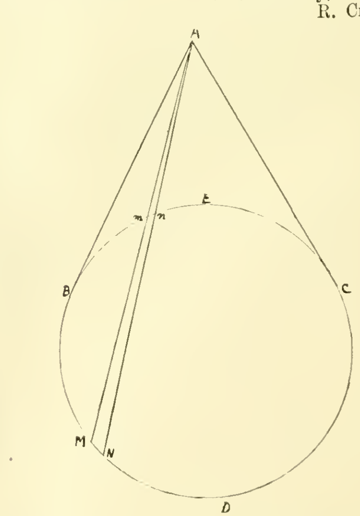


Fig. I.

Let B E C D be a section of a thin spherical shell, and A B C a section of a cone touching the shell.

It is easily seen that the attraction of the lower part B D C on A is exactly equal to that of the upper part B E C. Therefore, the attraction of the whole shell will

be double that of the lower part B D C. Now, let A gradually approach the shell, then the lower part B D C gets larger, but the attraction of the shell is still double of it; and ultimately, when A coincides with E, the attraction of the shell is double of itself. R. Chartres.

[This is perhaps too difficult for some of the readers of Knowledge, who may welcome a word of explanation.

The attraction of the lower part of the spherical shell B D C on a particle at A may be shown to be equal to the attraction of the upper part B E C, which lies within the enveloping cone B A C, by considering the attractions of the small portions of the thin shell cut out by a cone of very small angle with its vertex at A. We have M N is to $m\ n$ as A N is to A n, and the portion of the thin spherical shell intercepted at M N is to the portion intercepted at $m\ n$ as A N^2 is to A n^2. But the attractions on the particle at A are inversely as the square of the distance from A. Therefore, the portions intercepted on the nearer and further side of the shell will attract the particle at A equally. Hence,

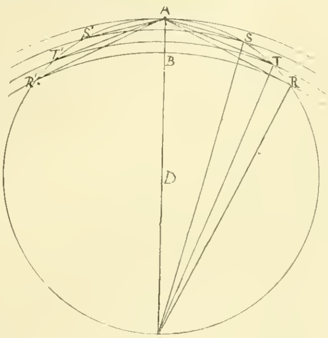


Fig. II.

the whole exterior portion B D C attracts a particle at A equally with the interior portion B E C. But this is only true for a shell the thickness of which vanishes compared with the distance of A from the shell. In the case of a particle approaching and ultimately resting on a shell of sensible thickness—we may determine the attraction by considering the shell as composed of a number of very thin concentric strata. In Fig. II. let S S′, T T′, R R′ represent thin concentric strata, with centre C, the particle being at A. Bisect A C in D, and with centre D describe the circle A S T R C. Then A S, A T, A R will be tangents to the circles S S′, T T′ and R R′, for the angles A S C, A T C and A R C are all right angles, since the points S T R lie on a semi-circle with diameter A C. The attraction of the portion of the thin spherical stratum R R′ within the enveloping cone will be equal to the attraction of the whole of the rest of the stratum, and so for any other thin stratum T T′ or S S′; consequently, for a shell of sensible thickness, the attraction of the material within the small sphere A S T R C R′ T′ S′ will be equal to the attraction of the whole of the rest of the shell.

In the case discussed by Mr. Chartres, when the spherical shell is thin there will be very little attracting matter within the smaller sphere described on the radius of the larger sphere as diameter, but as this matter is close to A the intensity of the attracting action will be considerable, and will balance the attracting action of the rest of the shell.—A. C. Ranyard.]

THE POTATO FUNGUS.

By J. Pentland Smith, M.A., B.Sc., &c., Lecturer on Botany, Horticultural College, Swanley.

In the "Travels and Life-History of a Fungus," chronicled in the June number of Knowledge, the nature of those lowly organisms termed Fungi was briefly sketched. The example then selected had an extremely interesting and complex life-history, but the reader will probably acknowledge that the form which is brought before his notice in this paper has an equally romantic story to tell. Its ravages have been the subject of much discussion lately in connection with the distress prevalent amongst the Irish peasantry, but that was not the first time that it had occupied the attention of the public and Parliament in this country. In fact, to quote the words of Dr. Plowright, in a lecture delivered lately at the Royal College of Surgeons, and reported in the *Gardeners' Chronicle*, "of all the plant diseases of fungoid origin, there is none which has aroused more general interest than that caused by the parasitic Fungus, known to scientists as *Phytophthora infestans*. This is one of the very few Fungi which can claim to having effected a change in the laws of our land. Politicians and reformers take credit to themselves for having, by dint of much writing and more talking, brought about the repeal of the corn laws, but there are those who still say, if it had not been for the Potato disease and the famine it caused in Ireland, this political change would not have taken place until long after it really did."

It was in 1845 that the first attack general over Great Britain and Ireland was noticed, but more localised attacks in this and neighbouring lands had been chronicled in previous years; they, however, were so slight as not to attract much attention. "So momentous a calamity as befell Great Britain and Ireland," says Dr. Plowright, "by the failure of the potato crop has seldom been equalled, and is quite without parallel in the records of food-supply in our time."

The Potato (*Solanum tuberosum*) belongs to the Natural Order, or group of plants, *Solanaceæ*. Its native place is the Cordilleras of Chili, and perhaps of Peru. Its parasite in this country doubtless attacked it in its native wilds. It is now upwards of 300 years since it was introduced into Europe, first by the Spaniards and afterwards by Raleigh, but until half a century ago no appearance of the *Phytophthora infestans* was noticed. We reserve a probable explanation of this curious circumstance until the description of the fungus itself.

During July and August, especially in sultry, damp weather, a pestiferous, sickening odour may be observed to arise from the potato-fields. An examination of the plants shows that they are evidently in a diseased state. The leaves are curled up, and they and the stems have a blackened appearance. This condition is the result of a visit of *Phytophthora infestans*. The first indication of the presence of the fungus is the appearance of dark patches on the leaves, then circular or oval patches of a whitish bloom arise as if by magic on the under surface of the leaves. Microscopic investigation reveals the cause to be of a fungoid nature. If the meteoric conditions are favourable for the further growth of the fungus the field of potatoes may be a blackened, putrescent mass in a few days.

Figure 1. is a semi-diagrammatic transverse section of a Tomato-leaf. The Tomato (*Lycopersicum esculentum*) belongs to the same natural order as the potato, and like it, especially when grown out of doors, is extremely liable to the attacks of

FIG. I.—Transverse section of leaf of tomato (semi-diagrammatic). The leaf is upside down. The mycelium (*m y*) of *Phytophthora infestans* is ramifying through the mesophyll tissue (*m*), and a gonidium bearing branch has found exit at a stoma.

this fungus, as the writer witnessed here last year. Other plants (such as the henbane) found in this order, are also subject to its attack. The natural position of the leaf is reversed, so that the under surface is uppermost. A thin stalk, which branches in the external medium, issues from a stoma. Ramifying between the mesophyll (middle-leaf tissue) cells are thread-like bodies connected with this branched stalk. The latter, in fact, is merely a prolongation of these threads. They are the hyphæ of the fungus mycelium* which nourishes itself at the expense of the nutrient matter in the cells of the plant, and induces the putrefactive action that may ultimately result in the total decomposition of the whole plant. This fungus is thus distinctly a parasite. The mycelium penetrates the cells by means of small processes, *haustoria*, or suckers; they seem to have a putrefactive action. The blocking up of the stomata or transpiring organs of the plant prevents free evaporation of water, and so hastens the decay initiated by the haustoria. The branching filament figured as proceeding from the stoma is only one of myriads that may be found on one plant. It is divided by a number of transverse divisions, and on the ends of some of the branches, as well as on the main stem, oval bodies are represented. Reference to Figure II. will show these more distinctly. The manner of growth of this branched stalk merits description. On the end of the stalk and of its branches a swelling appears, and is cut off in each case from the stem on which it arises by a transverse septum. The bodies so produced are reproductive cells as we shall presently see, and hence are termed *gonidia*. A slight swelling appears on the stalks below each gonidium, and afterwards growth in length takes place, the result being that the gonidia are pushed aside and stand almost at right angles to their pedicels. These prolongation pedicels repeat what has already been described, and so on.

FIG. II.—More highly magnified view of gonidium bearing shoot (*ad nat.*). *a*. A single gonidium (still more highly magnified); *b*. the same germinating.

A warm, humid atmosphere is especially favourable to the development of these organs. This can easily be shown by transferring a leaf with a poorly developed gonidiophore (gonidium-bearing branch) from a comparatively dry and cool medium to a bell-jar standing on water and situated in a warm room. A rich crop of gonidia is the result. These can live for three weeks in an atmosphere not perfectly dry. They are capable of germination in the presence of moisture. In germination the wall of the gonidium ruptures, and the protoplasm, enclosed in a very delicate membrane, protrudes as a small tube, which evidently secretes a ferment, for it can force its way through the cuticle of the epidermal cells of the leaf and thus find entrance into its interior. Once there it ramifies amongst the cells, absorbing their nourishment, and acting in every way like the parent from which it arose. If it be remembered that the gonidia may be present in countless numbers, the quick spread of the disease is easily accounted for.

In addition to this method of increase there is another asexual one. It generally happens that when plenty of moisture is present the protoplasm of the gonidia breaks up into eight pieces, each of which becomes more or less rounded off from its neighbour. The gonidium is now equivalent to a sporangium or spore-containing vessel, but as its contents have arisen asexually the term gonidangium is more applicable. In germination each portion of protoplasm sallies forth from the vesicle as an exceedingly minute body, furnished with two vibratile processes termed cilia, which are merely prolongations of its substance. Such bodies are called zoogonidia, on account of their capability of active movement. This they exhibit only in water or a nutritive fluid. They seem like animals, as they move rapidly about from place to place in the watery medium. Their exit from the gonidangium is prepared for by the swelling of the gelatinous apex of that body, and its almost simultaneous disappearance. At the same time the zoogonidia themselves absorb water, but their extrusion from the vesicle is directly caused by the swelling of the clear gelatinous inner wall of that body, and probably also of the clear layer that surrounds each zoogonidium. These bodies can live, and only in water, a very short time.

Suppose a few potato-plants in a large field of potatoes to be attacked by this pest, it is perfectly evident that the production of myriad zoogonidia on these during a damp, warm day will cause the rapid spread of the disease. For the smallest particle of moisture in the air affords a sufficient quantity of water for these minute bodies to live in. The passage of a dog or other animal through the field, and the visits of birds and insects, facilitate the spread of this dreadful pest.

The zoogonidia, if they find a suitable resting-place, at once germinate. This process, as a rule, takes place on the surface of a leaf. The cilia disappear, and a short tube is sent forth. Like that of the parent gonidium, it can pierce the epidermal cell-wall, and thus enter the leaf-substance. In the leaf it increases in length and branches like the parent mycelium. The hyphæ so formed produce gonidia and zoogonidia in their turn, and so the reproduction of the fungus may take place more than once in the course of a single summer.

Not only does the fungus affect the leaf, but it may enter the stem and even penetrate into the tubers. Moreover, in the young state the tubers are subject to the invasion of the gonidia and zoogonidia, to the former especially if they lie exposed on the surface of the soil. The latter, in certain soils, and in the presence of mois-

* For explanation of terms see "The Travels and Life-History of a Fungus," KNOWLEDGE, June, 1891.

ture, easily find their way to the young tubers beneath. The cuticle of these is so delicate that it affords no barrier to the entrance of the gonidial-tube.

According to De Bary, the processes described are the only means by which the fungus can reproduce itself, and the reader will doubtless be of opinion that such means are ample. A few years ago, however, Mr. Worthington Smith described the formation of sexual organs, and his observations were corroborated by other workers in this department of Botany. In leaves of the potato, towards the late autumn, and in diseased tubers, the products of the sexual organs are, as a rule, plentiful. A small branch of the mycelium, in one of the intercellular spaces, swells up in a globular fashion, and is cut off by a septum (division) from the rest of the hypha, to which, however, it is st ll completely adherent. On the same, or on a neighbouring hypha, a tubular protuberance arises which applies itself to the swelling just mentioned. Its contents are also divided from those of the rest of the hypha by a membranous partition. The first formed body is called the *oogonium*, or egg producing apparatus, the latter is the *pollenodium* (οἶδα, like) for a reason presently obvious (see Fig. III.). Both are densely filled with protoplasm. That of the oogonium divides into two parts, an inner more granular portion surrounded by a clear, delicate, cell wall, and called the ovum, or egg, and an outer less granular case the *periplasm* (περι, around, and πλασμα, a thing moulded). The protoplasm of the pollenodium exhibits differentiation of a like kind, although not so markedly. The ovum before fertilization has received the name oosphere. Where the pollenodium touches the oogonium, a small tube is sent out, which penetrates that organ and so reaches the *oosphere*. Then the central part of the pollenodium's protoplasm, the *gonoplasm* (γεννάω, to produce), is poured into the oospore, which is now called a fertilized egg, or *oospore*. The connection between the oogonium and the parent mycelium now ceases, and changes immediately take place in the former. A wall of cellulose is formed round the oospore, the periplasm contracts, and the wall of the oogonium remains as a covering until germination takes place. The oospore is a little spore, and the sac containing it, previously the female reproductive oogonium, is now a sporangium (Fig. III.).

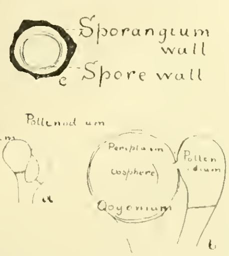


Fig. III.—The reproductive organs of *Phytophthora infestans* (?). *a* and *b*, diagrammatic, *c* (*ad nat.*).

The spore does not germinate at once. Ten months elapse before this can take place. The product of germination is one or more germ-tubes, which behave exactly like those of the gonidia; or the spore, like the gonidium, breaks up into a number of moving bodies, each furnished with two cilia, and so comparable to the zoogonidia. These are called zoospores, because their parent was a spore.

If we adopt Mr. Worthington Smith's view of the case, the spores are the resting stage of the fungus. It is almost impossible in any case to imagine that the mycelium is perennial in the tubers, that is, that it can live in these more than one year, when we know its putrefactive action on their cells. Yet it has been held by some that the mycelium is perennial. At present, however, the matter may be considered *sub-judice*.

The oogonia and pollenodia described by Mr. Worthington Smith have been held to belong to an allied fungus, a species of pythium. Dr. Plowright's remarks, in the lecture already referred to, are interesting in this connection: "All of us who have studied the potato disease have hunted for these resting spores. A few years ago, Mr. W. G. Smith thought he had found them, and most of us thought so too, but it was subsequently shown by the late Professor De Bary, that spores closely resembling Smith's resting spores, very commonly occurred in potato plants kept in damp situations, which belonged to a species of pythium. Since this time we have been unable to meet with a sexual spore, which upon germination is capable of giving rise to the phytophthora, and although the probability is that such a spore does exist, yet there the matter rests."

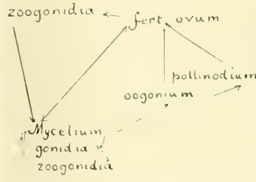


Fig. IV.—Diagrammatic representatives of life-history of *Phytophthora infestans* (the potato-disease fungus).

The temperature of the air has a great influence on the development of this fungus. Above 77° F. the mycelium is killed, and below 40° F. the production of gonidia ceases. About 70° F. may be reckoned as the most productive temperature. In its native place, as we formerly remarked, the potato was undoubtedly attacked by this parasite, although for well-nigh 300 years it had not made its appearance in Europe. It has been affirmed that the high temperature of the regions surrounding its native habitat, localised that of the phytophthora, and also that in passing through the torrid zone any infected tubers were sterilized, that is, were completely ridded of their dread enemy. Nowadays, steamers have replaced sailing vessels, making the passage through the torrid zone of exceedingly short duration, so that the fungus is not killed in the transit of the potato from Chili to Europe. Doubtless also, the same authority remarks, the guano trade has done much to further the spread of this pest, whose life-history can be seen at a glance by reference to Figure IV.

THE FACE OF THE SKY FOR JULY.

By Herbert Sadler, F.R.A.S.

THE solar surface is still active. Until about the 20th of the month there is no real night in the British Islands. The following are conveniently observable times of the minima of some Algol type variables (*cf.* "Face of the Sky" for June): Algol.—July 16th, 0h. 33m. a.m.; July 19th, 9h. 22m. p.m. δ Libræ.—July 4th, 11h. 8m. p.m.; July 11th, 10h. 43m. p.m.; July 18th, 10h. 17m. p.m.; July 25th, 9h. 51m. p.m. U Coronæ.—July 28th, 11h. 10m. p.m. U Ophiuchi.—July 5th, 11h. 0m. p.m.; July 10th, 11h. 47m. p.m.; July 16th, 0h. 32m. a.m.; July 26th, 10h. 12m. p.m.; July 31st, 10h. 57m. p.m. Y Cygni, July 2nd, 9h. 12m. p.m.; July 5th, 9h. 7m. p.m.; July 8th, 9h. 2m. p.m.; July 11th, 8h. 57m. p.m.; July 14th, 8h. 51m. p.m. Variable of short period, not of Algol type. η Aquilæ.—July 5th, 1h. a.m. Maximum of S Ursæ Majorii (*cf.* Mr. Peek's paper in Knowledge for March, 1890) on July 21th.

Mercury is not favourably situated for observation in

July, being in superior conjunction with the Sun on the 7th. During the latter part of the month he is an evening star, setting on the 31st at 8h. 41m. P.M., or 54m. after the Sun, with an apparent diameter of $5\frac{3}{4}''$ and a northern declination of 12°, about $\frac{3}{4}$ of the disc being illuminated. Venus is a morning star, but is not a particularly attractive object in the telescope during the month. On the 1st she rises at 2h. 24m. A.M., or 1h. 24m. before the Sun, with an apparent diameter of $10\frac{1}{2}''$ and a northern declination of 22° 18′, about $\frac{93}{100}$ of the disc being then illuminated. On the 31st she rises at 3h. 7m. A.M., or 1h. 17m. before the Sun, with an apparent diameter of 10″ and a northern declination of 21° 32′, $\frac{97}{100}$ of the disc being then illuminated. During the month she passes through part of Taurus and nearly the whole of Gemini. Mars is invisible. But for her great southern declination, Vesta would still be excellently placed for observation, southing on the 5th at 11h. $1\frac{1}{2}$m. P.M., with a southern declination of 21° 38′, and on the 29th at 9h. 13m. P.M., with a southern declination of 23° 20′. She continues to be visible to the naked eye throughout the whole of July.

Jupiter is an evening star, rising on the 1st at 11h. 5m. P.M., with a southern declination of 5° 53′ and an apparent equatorial diameter of $43\frac{1}{4}''$. On the 31st he rises at 9h. 6m. P.M., with a southern declination of 6° 22′ and an apparent equatorial diameter of 47″. He describes a very short retrograde path in Aquarius during the month, and on the night of the 28th is about 14′ north of the $6\frac{1}{2}$ mag. star B.A.C. 8129. The following phenomena of the satellites occur before midnight, while Jupiter is more than 8° above and the Sun 8° below the horizon :—On the 15th, a transit egress of the shadow of the first satellite at 11h. 14m. On the 22nd, a transit ingress of the shadow of the first satellite at 10h. 49m.; a transit egress of the third satellite at 11h. 25m.; a transit ingress of the first satellite at 11h. 51m. An eclipse reappearance of the fourth satellite on the 23rd at 11h. 11m. 38s.; an occultation reappearance of the first satellite at 11h. 20m. On the 29th, an eclipse disappearance of the second satellite at 11h. 5m. 23s.; a transit egress of the shadow of the third satellite at 11h. 24m., and a transit ingress of the satellite itself 14m. later. On the 31st, a transit egress of the second satellite at 10h. 10m.; and a transit egress of the first satellite at 10h. 21m.

Saturn is so rapidly nearing the west that we only give an ephemeris for the first half of July. Saturn sets on the 1st at 11h. 9m. P.M., with a northern declination of 8° 44′ and an apparent equatorial diameter of 16·6″ (the major axis of the ring-system being $38\frac{1}{4}''$ in diameter, and the minor axis 3″). On the 16th he sets at 10h. 11m. P.M., with a northern declination of 8° 13′ and an apparent equatorial diameter of $16\frac{1}{4}''$ (the major axis of the ring-system being $37\frac{1}{2}''$ in diameter and the minor $2\frac{1}{2}''$). During this time he describes a short direct path in Leo. Iapetus is at his greatest western elongation, when he is brightest, on the 13th. Uranus is an evening star, rising on the 1st at 1h. 51m. P.M., with a southern declination of 10° 1′ and an apparent diameter of 3·6″. On the 31st he sets at 10h. 19m. P.M., with a southern declination of 10° 8′. He is in quadrature with the Sun on the 20th, and is almost stationary to the N.N.E. of 86 Virginis during July. Neptune is invisible.

Shooting stars are fairly numerous in July, though the twilight interferes with observation. A well-marked shower radiates from near δ Aquarii, the maximum being on the 28th. The radiant point is in 22h. 40m.—13°.

The Moon is new at 3h. 59m. A.M. on the 6th; enters her first quarter at 5h. 29m. A.M. on the 14th; is full at 1h. 54m. P.M. on the 21st; and enters her last quarter at 4h. 33m. A.M. on the 28th. She is in apogee at 6h. P.M. on the 11th (distance from the earth, 251,610 miles); and in perigee at 5h. P.M. on the 23rd (distance from the earth, 224,325 miles). The greatest western librations take place at 5h. 44m. A.M. on the 4th, and at 5h. 24m. P.M. on the 30th; and the greatest eastern at 9h. 16m. P.M. on the 17th.

Whist Column.

By W. Montagu Gattie, B.A.Oxon.

THE following is an elementary explanation of the play of the hand published last month. For convenience of reference, the distribution of the cards is here repeated :—

H. 9, 8, 7.
S.—8, 7, 4.
D.—8, 6, 2.
C.—10, 7, 5, 4.

Z

H.—Kg, Kn, 6, 3.
S.—Ace, Kn, 2.
D.—Kg, 9.
C.—Qn, 9, 6, 2.

B — Z turns up the seven of Hearts. — A

H.—Qn, 4.
S.—Qn, 3.
D.—Ace, Qn, Kn, 5, 4, 3.
C.—Kn, 8, 3.

Y

H.—Ace, 10, 5, 2.
S.—Kg, 10, 9, 6, 5.
D.—10, 7.
C.—Ace, Kg.

Score — Love all.

Tricks 1 *and* 2.—Holding more than four diamonds, A rightly follows the ace with the knave; with four only, he would lead the ace and then the queen. Y can place the queen in A's hand; and the cards played by B and Z show that A also has the five, four, and three of diamonds, unless B is calling for trumps, in which case he may have one small diamond. The only diamond Z can have left is clearly the eight.

Trick 3.—B holds four trumps to two honours, and his partner's diamonds are established. Under these circumstances he does right in opening trumps.

Trick 4.—Y, of course, opens his long suit of spades. He infers from the fall of the cards that B has the knave, for, if either Z or A had had it, he would have played it.

Trick 5.—A returns his partner's trump lead. It is worth noticing (although the inference is not of service in this particular hand) that Y can now place the remaining trumps. This will readily be perceived if it be remembered that A would return the higher of two remaining cards, and that B's lead and subsequent play show four trumps to the king.

Trick 6.—B cannot yet tell whether his partner is void of trumps or has two more; but in either case he plays correctly in continuing them. A, having to discard, disposes of his worthless spade.

Trick 7.—It will be seen that A B have now shown "two by honours," and have already secured five tricks; therefore they require four more tricks to make the game. B is protected in clubs, and has command of the adverse spades, and, if he had another diamond, he could not do better than to lead his losing trump; for, on recovering the lead, he would play the diamond, and, trumps being out, A would make all the remaining diamonds. B, however, has not a diamond, and therefore A's winning cards in that suit will be of no use unless he has a card of re-entry. The king of spades is, in all likelihood, with Y, so that the

best chance is that A may be able to take a trick in clubs. Suppose, now, that A holds the king of clubs, and that Y has the ace. If B follows the rule and leads a small club from his four cards in that suit, the king will fall to the adverse ace, and A's prospect of bringing in his diamonds will be at an end. But, if B leads his queen of clubs, as though he had only three of the suit, the queen will draw the ace, and A's king will enable him to win the game. Of course A may not have any strong club, but in that event B cannot expect to make four more tricks, and he is, at the most, sacrificing one trick in making a bid for the game.

Trick 8.—Y has the winning trump; but he could not tell from trick 4 whether B or A had the ace of spades. He therefore reserves his trump to ruff A's diamonds, in case the ace of spades should be with A. B finesses the knave of spades as a matter of course (see trick 4), and A, equally of course, discards a diamond, so as to keep his knave of clubs guarded.

Trick 9.—B pursues the same tactics as at trick 7, and it will be observed that he has now so far succeeded in his object that A's knave of clubs is cleared.

Trick 10.—Y sums up the situation as follows:—Of five spades unplayed, he himself holds three; and, as B must have the ace, Z can only have one (the eight). If B has both ace and eight (which in strictness should not be, for in that case he ought to have finessed the eight at trick 8, seeing that Z could play nothing better than the seven at trick 4), Y can be sure of saving the game by making a spade. But, supposing that Z has the eight of spades and also the eight of diamonds (see note to tricks 1 and 2), he cannot have any more of either suit, so that he must have at least two clubs. B, having followed the queen of clubs with the nine, is not to be credited with either knave or ten; and, as A must have at least three diamonds, he can only have one club, so that one of Z's clubs must be either knave or ten. He should not hold both knave and ten, as, in such case, he ought to have covered B's nine; therefore either knave or ten may be placed in A's hand. In the former case it will be fatal for Y to draw the losing trump from B, for A will win all the remaining tricks; but, if Y retains his trump to ruff the knave, B, after winning trick 12 with the smaller trump, will have to lead a club, and the last trick will fall to Z. If the knave of clubs should turn out to be with Z, Y Z would perhaps make another trick by Y's drawing the trump, but this possibility is not worth consideration against the certainty that, in the other event, the game would be lost.

Chess Column.

By C. D. Locock, B.A.Oxon.

To Correspondents.—All communications for this column should be addressed "*Cintra, Hawkhurst*," and posted *before* the 10th of each month. For the words "Chess Problem Tournament" in our last issue, "Problem *Solution* Tournament," should be read. It is not *necessary*, therefore, for competitors to compose or send problems. They are merely invited to send original problems (not more than one by each competitor can be inserted).

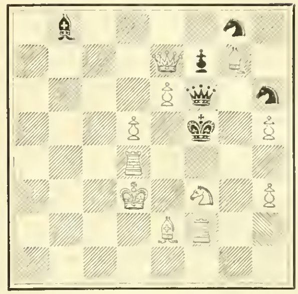
The Solution Tourney begins with the problem below. The conditions of the competition were fully set forth in the June number.

Solution of Problem in June number: 1. K. to R4, and mates next move. Correct solution from C. T. Blanshard.

PROBLEM.

By W. E. Bolland.

Black.



White.

White to play, and mate in two moves.

The Championship Tournament of the City of London Chess Club has again been won by Mr. R. Loman, the well-known musician, who defeated Mr. Moriau in the final tie, after a close contest.

The following game was played on May 13th, in the match between the British and City of London Chess Clubs:—

King's Gambit Declined.

White. G. T. Heppell (City).	Black. H. W. Trenchard (B.C.C.).
1. P to K4	1. P to K4
2. P to KB4	2. P to Q4
3. Kt to KB3 (*a*)	3. P × KP
4. Kt × P	4. Kt to QB3 (*b*)
5. B to Kt5	5. B to Q2
6. Q to R5 (*c*)	6. P to KKt3
7. Kt × Kt	7. P × Q (*d*)
8. Kt × Q	8. R × Kt (*e*)
9. Kt to B3	9. Kt to B3
10. P to QKt3	10. B to QKt5 (*f*)
11. B × B ch (*g*)	11. R × B
12. B to Kt2	12. Castles (*h*)
13. Castles (Q side) (*i*)	13. KR to Qsq (*j*)
14. P to KR3 (*k*)	14. B × Kt
15. B × B	15. Kt to Q4
16. KR to Ksq (*l*)	16. Kt × B
17. P × Kt	17. R × R ch
18. R × R	18. R × R ch
19. K × R (see Diagram)	19. P to R5 (*m*)
20. K to K2	20. P to KB4
21. P to B4 (*n*)	21. K to B2
22. P to R3 (?)	22. K to K3
23. K to K3	23. K to Q3
24. K to Q4	24. K to B3
25. P to B3	25. K to Kt3 (*o*)
26. K to K3 ? (*p*)	26. K to B4
27. K to K2	27. P to QR4
28. P to R4	28. P to B3
29. K to K3	29. P to Kt3
30. K to K2	30. P to Kt4
31. RP × P	31. P × P
32. P × P	32. K × P
33. K to K3	33. P to R5
34. P × P ch	34. K × P
35. K to Q4	35. K to Kt4
36. K to K3	36. K to B5
37. K to Q2	37. K to Kt6
38. Resigns (*q*)	

Notes.

(*a*) At least as good as the usual P × P.

(*b*) Not so good as B to K3, preventing B to B4, for White can now get a slight advantage by Kt × Kt.

(*c*) The combination is not quite sound. Kt × B is probably better.

(*d*) P × Kt might lead to the following continuation: 8. Q to K5 ch, Q to K2; 9. Q × R, Kt to B3; 10. B to R6!, B to Bsq!; 11. B × B or B to K2, followed by P to KKt4 saving the Queen.

(*e*) Overlooking the winning advantage to be obtained by 8. . . . B × B; 9. Kt × KtP (the Bishop if attacked retires to QR3) 9. . . P to QR4!; 10. P to Q4 (he must make a square for the Kt); 10. . . . P × P *en passant*; 11. B to Q2, P × P; 12. Kt to R3, B × Kt, followed by B to B3, B × P and B to K5. Or if White play instead 11. B to K3, there follows equally 11. . . . P × P; 12. Kt to B3, B to B3, and 13. B × P, with two Pawns ahead at least for the time.

(*f*) The Bishop is best where he is for the present. He should play R to KKtsq; and if then 11. P to Kt3, P to R5, quickly breaking up White's position on the King's side.

(*g*) Of course he dare not play B to Kt2 at once, on account of the reply B × B, winning a Pawn.

(*h*) Again R to Ktsq is much better (*vide* note *f*). The King is best in the centre of the board.

(*i*) It is necessary to defend the KBP.

(*j*) For now Black could at once obtain a passed Pawn by B × Kt, 14. B × B, Kt to Q4, &c.

(*k*) Very weak. KR to KBsq was essential.

(*l*) The other Rook should be played to this square, in order to avoid the exchanges. Obviously Black dare not play to win a Pawn.

(*m*) A fine move, blocking the Pawn position, and leaving two moves for his other KRP to gain time with if necessary.

(*n*) This and his next move are grave errors. The Pawns should not be moved till necessary; and especially the RP, which has the option of moving one or two squares later on, according to need. He should simply come out with the King.

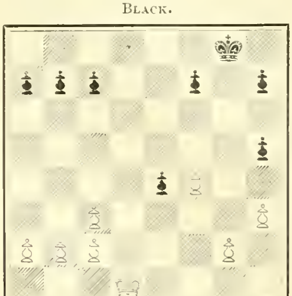
(*o*) Black wisely refrains from moving any of his Pawns till, by doing so, he can force the position.

(*p*) Unaccountable. P to B5 ch (if not any other move) would almost certainly draw. The rest now is easy for Black.

(*q*) For Black can gain the opposition by moving the RP; *vide* note (*m*). The ending is very well played by Mr. Trenchard.

Position after White's 19th move.

Black.



White.

KNIGHTS AND BISHOPS.

It is generally admitted that these pieces are of about the same value, but it may not strike everyone on what grounds this conclusion is based. The two pieces have absolutely nothing in common, so that mathematical accuracy of valuation is out of the question. A Bishop's action is like that of a rifle-bullet at long range, direct and swift: a Knight's more like a bomb-shell, explosive in all directions. Most players have a preference for one piece or the other: "Winawer's Knights" are almost as proverbial as "Paulsen's Bishops"; the move, B × Kt. (if possible, doubling a Pawn) being known to the profession as "Winawer's Trade Mark." Mr. Steinitz prefers the Bishop, holding with the ancient dictum that six Bishops are worth seven Knights. Most amateurs, we fancy, have a lurking partiality for the Knight. There is a certain fascination in calculating how many moves it will take a Knight to reach a particular square: the calculation has the merit of combining depth with easiness. The Bishop is in reality a more difficult piece to manœuvre well.

But how are their values to be compared? Take first a simpler case, that of Rook and Bishop. The Rook has obviously five distinct advantages. (1) On a clear board it commands 14 squares from any position; whereas, the Bishop commands its maximum of 13 squares, only if placed on one of the four centre squares. (2) A Rook can, if necessary, command any square on the board; a Bishop is, of course, limited to the squares of one colour. (3) A Rook can confine a King, a Bishop cannot. (4) Rook and King can mate, Bishop and King cannot. (5) Rook assists King to castle. Against all this is to be set the Bishop's one advantage, the power of being brought earlier into play. A Rook, therefore, is evidently far stronger than a Bishop. Going back, now, to the case of Knight and Bishop, we find that points (3), (4) and (5) are not available for comparison. Points (1) and (2) may be discussed first, and then the other respective advantages of the two pieces must be simply counted up, and, when possible, balanced one against the other.

(*To be continued.*)

Contents of No. 68.

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CONTENTS.

NOTICE.

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GNATS, MIDGES AND MOSQUITOS.—II.

By E. A. Butler.

As already intimated, Gnats and Mosquitos are amongst that section of the "thread-horned" flies whose early life is aquatic, and a truly remarkable history is theirs. That creatures so fragile should have at any time any connection with so unstable and treacherous an element as water is indeed strange, and unquestionably large numbers perish through the mischances involved in this very association; nevertheless, so great is their fecundity that the race runs no risk of extermination, notwithstanding the dangers that beset the path of the individual in its advance to maturity. The eggs are long oval objects, and from the time of laying they are entrusted to the water. The female, when about to lay, rests with her first pair of legs on some floating stick or leaf or other support, the second pair gently touching the water, while the third project over its surface. Crossing these like an X, she allows an egg to pass into the angle where they meet; this is soon followed by another and another, their moist and glutinous surfaces causing them to adhere to one another with the long axis nearly perpendicular. In this way a collection of some 200 or 300 is built up into the form of a tiny raft, concave above—a sort of miniature life-boat, so constructed that no capsizing can take place. The egg-raft once made, the maternal duties are over, and the little craft drifts rudderless away, exposed to sun and storm. This venturesome voyage, however, lasts but a few days, and then, the eggs having been from the first placed upside down in the water, the lower end of the shell is forced off, and the newly-hatched grub finds itself at once in position to take a header into the watery world in which it has to pick up its living.

These larvæ are odd-looking objects, foreshadowing the form of the adult to a somewhat greater extent than is usually the case with those insects which pass through a complete metamorphosis. The three regions of the body are distinctly marked out, quite the reverse of what obtains amongst the "short-horned" flies, whose shapeless "maggots" we described in a former number. If we imagine the full-grown Gnat's body to be bereft of all its long appendages—wings, legs, antennæ, and beak—and to be provided at intervals with tufts of hair instead, we get some idea of the outline of the larva. They move by a series of jerks, accomplished by swaying the body from side to side, and the natural position is head downwards. Though living in the water they inhale air, and hence come to the surface occasionally to breathe. The entrance to the breathing tubes is at the end of a sort of arm or branch jutting out from the hinder—*i.e.*, the upper—end of the body, and all that is necessary for taking in a fresh breath is to expose this little orifice just above the surface of the water. The larva is furnished with biting jaws, and spends a good deal of its time in devouring all sorts of rubbish and decaying matters, such as may be found in abundance in the pond it inhabits. Thus it swims about with tail most appropriately pointed to the sky, and head to the muddy bottom, where lie its chief stores of food.

It is easy to understand that thousands of these larvæ, working away in a pond on the decaying organic matter there, will do a good deal towards arresting the pollution of its waters, and Gnats, therefore, in this stage of their life may be regarded as sanitary agents, of more or less use to society at large. It follows, then, that their extermination from any district might not be altogether an advantage, unless accompanied by other changes, such as drainage, &c.; and in estimating the influence of Mosquitos, for example, in the economy of Nature, one has to set their services as scavengers over against the annoyance they cause by sucking blood. It might be a philosophical, if not very comforting, reflection for anyone suffering from the persecutions of these pests, that the more Mosquitos there are, the more scavenging work must have been done in bringing them to maturity, and the more must the sanitary condition of the country round have been thereby improved! There is another curious fact connected with this stage in the life-history of these insects; when fully grown, as we have already seen, they subsist only on liquid food, their mouth organs being excellently fitted for taking in liquids while they would find it absolutely impossible to make any use of solid food. But

in this earlier stage, the conditions are reversed; solid food is the order of the day (though plentifully steeped in water, it is true), and no sucking apparatus exists, the mouth being armed with biting jaws instead.

The change, however, is not suddenly made from the one style to the other. There intervenes a condition in which the insect takes no food at all, either solid or liquid, having no available mouth; for, when several moultings of the jerky larva have taken place, it makes another change of skin which results in an entire upsetting of all its arrangements. After this moult it appears as a kind of animated "comma," with a big head and a curved tail. The apparent head is really head, thorax, beak, antennæ, limbs and wings of the perfect insect, all bound together under a thin skin, sufficiently transparent for the individual parts to be traced from without, as shown in the photographs last month; the "tail" is, of course, the abdomen, and it is terminated by a couple of broad leaf-like paddles (Fig. 2) of exquisite structure, which form a sort of sculling apparatus. It no longer jerks about head downwards, but, turning a somersault, passes the next stage of its life right way up, notwithstanding its apparently top-heavy shape. Conformably with the altered position, though whether as cause or consequence it is not easy to say, the opening to the breathing organs is now on the thorax. Two horn-like projections (Fig. 3) are here seen, which are the prolonged lips of the spiracles. Into these is taken, by periodical visits to the surface, whatever air may be necessary for breathing purposes; such visits are, however, by no means frequent, the insect being capable of enduring prolonged submergence without inconvenience. The pupa is as capable of active exertions as was the larva, and in fact is freely locomotive, though it takes no food. This is a most exceptional circumstance amongst insects with a complete metamorphosis. Nothing, moreover, could be in stronger contrast to the style of life of the "short-horned" flies than that of this roving Gnat pupa. It will be remembered that the blow-fly, which may be taken as a type of the "short-horns," when about to become a pupa, does not cast its skin, but becomes a barrel-shaped, absolutely motionless body, by the hardening of the last larval coat, whereas the Gnat or Mosquito *does* cast its skin to become a pupa, and that pupa is a lively, wriggling creature, free to wander whither it chooses, though no more capable of feeding itself than the aforesaid barrel.

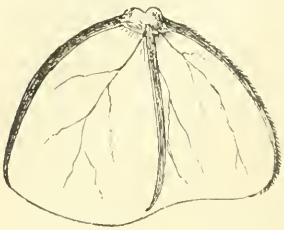


FIG. 2.—Terminal paddle or leaflet of pupa of a species of Gnat (*Corethra plumicornis*).

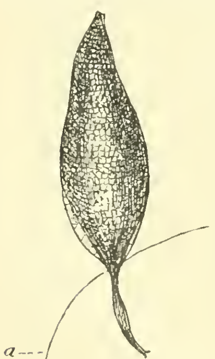


FIG. 3.—Spiracular horn of same Gnat.—*a*. Outline of thorax.

When the time for the emergence of the perfect insect arrives, which will be about a month after the hatching of the eggs, the pupa ascends to the surface, and, tipping up its tail, lies in a nearly horizontal position with the back of the thorax just above the water. The skin now splits, and the fly gradually extricates itself, of course in a limp condition and incapable of flight till its wings are dried and stiffened. The empty shell of the pupa gives it foothold till it is strong enough to spread its wings and mount into the air for the first time in its life. The occasion of the transformation from pupa to fly is evidently the supreme moment in the Gnat's career, and the risks involved are considerable. Not merely is it still exposed, as it has been hitherto, to the jaws of hungry fish or predaceous water insects, but there are also chances of wind and weather that may prove fatal. However, vast swarms escape these perils and rise into the air, where new dangers await them in the form of cobwebs and insectivorous birds, not to say human beings as well.

We have now followed our Gnat or Mosquito through a complete cycle of changes, and have thus seen that it is essentially an insect not of the house but of the pond, the marsh, and the swamp, whence it follows that blood-sucking is a practice that can but occasionally be indulged in, and it seems probable that great numbers of Gnats perish without ever tasting such food at all, and that in fact the habit is an acquired one and not really essential to their existence. If this be so, it is all the more remarkable when taken in conjunction with the extraordinary perfection of the blood-sucking apparatus, and the problem of their economy is as difficult to solve as that of the fleas on the sea-shore far from human habitations, to which we referred some time ago. Gnats, however, seem to be quite ready to drink the juices of flowers if they cannot get blood, and several observers have chronicled their fondness for honey. But still this will scarcely explain the presence of needle-like piercers amongst the mouth organs, since such instruments would not be necessary to get at the nectar of flowers.

In the days when every house had its water-butt, and when stagnant ponds abounded on every side, often in close proximity to human dwellings, the conditions were so much the more favourable for the multiplication of Gnats, and wherever such conditions now obtain, the insects are still likely to be both numerous and troublesome. But the extensive abolition of the water-butt, the introduction of closed and indoor cisterns, and the better drainage of the land, have all tended to throw hindrances in the way of the *Culicidæ*, and have helped to reduce their numbers in our own country, whatever may be the case elsewhere. There is evidence enough of this in literature. Enormous swarms of Gnats, of one kind or another, seem formerly to have been a not unusual experience, though such a thing now scarcely ever occurs here. The poet Spenser, for example, mentions as a familiar sight "a swarme of Gnats at eventide" that "out of the fennes of Allan doe arise,"

> "Whiles in the air their clust'ring army flies,
> That as a cloud doth seem to dim the skies":

and that *Culices* are intended seems certain, since they persecute man and beast

> "Till the fierce northern wind with blust'ring blast
> Doth blow them quite away, and in the ocean cast."

There are several records of swarms that have looked in the distance like clouds of smoke, and have consequently given rise to an alarm of fire, as was the case at Salisbury Cathedral in 1736. According to Prof. Riley, the northern Mosquitos of America pass the winter in the perfect state, hybernating in a semi-torpid condition, and a writer in *Insect Life* describes an enormous congregation of them as having been found hybernating in the corner of a cellar. This habit does not appear to hold good in all parts of the world.

A very peculiar connection between human beings and

Mosquitos has been made out in recent years. It is well known that there is a class of worm-like creatures, differing from the earthworm and other similar animals in not having the body divided into a series of rings, that inhabit various parts of the bodies of vertebrate and other animals. Man is subject to the attacks of several parasites of this sort, and shares them with other animals—*i.e.*, the parasites pass through their early life in the body of one host, and their later life in that of another. Numerous experiments and investigations, by Dr. Manson and others, seem to have proved that such a connection exists between man and a particular kind, or some few kinds, of Mosquito. The parasite is called *Filaria sanguinis hominis* (the thread-worm of the blood of man). The adult female of this creature inhabits the lymphatic glands of man, and is the cause of the curious and repulsive disease called elephantiasis, and of kindred maladies. Embryos produced from these sexually mature forms, pass from the lymphatic system into the blood of man and circulate with it, causing in this stage certain kidney diseases. No forms intermediate between these two have been found in man, and it is therefore evident that the intervening stages of the life of the parasite, whatever they may be, are spent elsewhere. From the blood of man, the embryos pass into the body of the Mosquito as it sucks its victim. Only a few of these seem to be digested with the blood; the rest escape from the Mosquito's digestive tube and establish themselves in its thorax, at the same time undergoing a change of form indicative of an advance in development. Thus far the history of the parasite has been traced, but exactly what happens afterwards is still to some extent a mystery. The Mosquito infested with *Filariæ* appears soon to die, the parasite apparently subsisting on the contents of its thorax. It has been thought that the Mosquito's body falling into the water on its death, the parasites escape and pass a free existence for a time, being after a while re-introduced into a human host by the drinking of the water that contains them. In investigating these facts, Dr. Manson got a Chinaman whose blood was known to contain *Filariæ* to sleep in a small curtained chamber placed in a larger room in which Mosquitos were flying. The door of the "Mosquito house" having been left open for some hours after the man had gone to sleep, was then closed, and the Mosquitos which had entered were thus entrapped. These were found in the morning clinging to the netting, gorged with blood, and were carefully collected day by day, and preserved; some were examined under the microscope at once, others not until after an interval, so as to secure a later stage of the parasite; in this way, by the examination of large numbers of the insects, after intervals of different length, the fate of the swallowed *Filariæ* was at length made out up to the point indicated above.

One of the most curious of the annoyances that have been recorded as occasioned by Gnats was illustrated in some specimens exhibited at a meeting of the Bristol Naturalists' Society in 1878. Mr. J. W. Clarke showed some sheets of writing paper from Sweden which formed part of a large consignment that had been greatly injured during the process of manufacture through a swarm of Gnats having got mixed up with the pulp. The remains of the flies were to be seen in the material of the paper, and some specimens were so perfect as to be easily identified as a *Culex*, and all seemed to belong to the same species. Another record is made of a Centipede similarly preserved in paper, and no doubt paper manufacturers could supply many others, though perhaps few on so extensive a scale as that alluded to above.

(To be continued.)

THE LIFE-HISTORY OF FILARIA SANGUINIS HOMINIS.

By JOSEPH W. WILLIAMS.

THE curious parasite, whose life-history we are about to relate, is found in the blood of persons suffering from a disease termed chyluria, which is characterized by the presence of chyle in the urine, and which occurs in certain tropical and subtropical countries, especially in Brazil, Mauritius, the Isle of Bourbon, Bombay, the West Indies, South Carolina, and Queensland. Cases now and again occur in Europe—one such came under my notice two years ago in a native of India—but, in the majority of instances, the persons affected have visited the tropics at some period of their lives. Five cases are, however, known to have occurred sporadically, and out of these two have been recorded in England—one in Lancashire, by Dr. William Roberts, and another in Norfolk, by Dr. Beale. The general range of the disease is within the limits 30° south and 30° north latitude. Probably, what is known as elephantiasis arabum—which must not be confounded with elephantiasis græcorum or leprosy—is also to be attributed to the presence of the same parasite.

This parasite has only been known to science in recent years. In 1866, Dr. Wucherer found several specimens at Bahia, in the urine of a patient suffering from chyluria, and two years later, Dr. Salisbury described, under the name of *Trichina cystica*, some worms which he had found in the urine of an insane person, and which now appear to have been nothing else than *Filaria sanguinis*. About the same time, Dr. Lewis of Calcutta, not knowing of Wucherer's discovery, called attention to observations that had been made by him of a similar character, and in 1872 he published that he had found nine specimens of the same kind of hæmatozoon in some blood which he had extracted from the finger of a Hindoo who was suffering from elephantiasis arabum. Dr. Lewis had sent specimens of his first case to Dr. Parkes and Mr. Busk in this country, and they had diagnosed them as belonging to the Filaridæ; and afterwards he gave to them the name of *Filaria sanguinis hominis*. These, however, were all cases of the discovery of the immature or embryonic worms. The mature worm was discovered in 1876 by Dr. Bancroft at Brisbane, and in the early part of the next year by Dr. Lewis in India. Dr. Cobbold then gave to it the name of *Filaria Bancrofti*, a name which has been rightly discarded for the prior one of Dr. Lewis. Since then the mature worm has been seen by Drs. Los Santos and Aranjo in Brazil, and by Dr. Manson in China. It is interesting to note that the mature worm is only known to exist in the lymphatics of its host, and that the immature or embryonic worm is found not only in the chyle but also in the blood.

The female worm is about 3 inches in length and about $\frac{1}{100}$th of an inch across, of an opalescent colour, thread-like, and appearing "like a delicate thread of catgut, animated and wriggling." The head is club-shaped, the mouth circular and destitute of papillæ, and the body devoid of transverse striations. Except an alimentary canal, which runs a straight and narrow course from head to tail, the body is made up almost entirely of the reproductive organs. The animal is viviparous, and is *continually* giving birth to fully-formed embryos. These embryos are of about the $\frac{1}{75}$th to $\frac{1}{50}$th of an inch in length, and about the $\frac{1}{3200}$th or $\frac{1}{3500}$ of an inch in diameter. They are thread-like (see Fig. 1), and enclosed in a sheath, like a baby in a caul. When examined under the microscope in a drop of blood they exhibit quick eel-like movements, lashing the red

corpuscles in all directions. The number of them in the blood of a person affected with the disease of which they are the concomitants must be enormous, and Dr. Stephen Mackenzie has reason to believe that the blood of a patient who came under his care contained from thirty-six to forty millions. The eggs are about $\frac{1}{500}$th by $\frac{1}{750}$th of an inch in length. A complete specimen of the male form has not yet been obtained, but Dr. Lewis found a broken specimen half an inch in length and $\frac{1}{180}$th of an inch across. It was thinner and firmer in texture than the female, and showed a great tendency to coil.

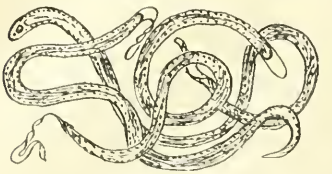


FIG. 1.—Embryos of *Filaria sanguinis hominis.*

The following measurements of a female specimen will serve to distinguish this species from any other Filarian:—

	Of an Inch.		MM.
Oral aperture to end of œsophagus ...	$\frac{1}{55}$	or	·45
Diameter of oral aperture	$\frac{1}{3000}$	,,	·008
Width of neck	$\frac{1}{545}$	,,	·045
,, about $\frac{1}{4}$ inch from anterior end ...	$\frac{1}{153}$	,,	·162
,, where packed with ova and embryos	$\frac{1}{100}$	,,	·25

Comparing its characters with those of *Trichina spiralis* and the embryo of the Guinea worm (*Filaria medinensis*), the only two human parasites with which it may be confounded, we have—

	Average Breadth.	Average Length.	Proportion of Breadth to Length	Aspect of Head.	Aspect of Tail.	Tail to Total Length
Trichina spiralis	$\frac{1}{700}$ in.	$\frac{1}{25}$ in.	1 to 28	Pointed	Blunt	
Filaria medinensis... .. [Embryo.]	$\frac{1}{1000}$ in.	$\frac{1}{32}$ in.	1 to 31	Rounded	Acutely pointed	1 : 3½
Filaria sanguinis hominis .. [Embryo.]	$\frac{1}{3500}$ in.	$\frac{1}{75}$ in.	1 to 46	Rounded	Acutely pointed	1 : 8

The greatest peculiarity of these parasites is their diurnal variation. If the blood of an affected person be examined between 6 a.m. and 6 p.m. none, or only a few, can be detected, while at 9 p.m. they are more abundant, and at or about midnight the blood is swarming with them. About 3 a.m. their numbers begin to appreciably decline, and at 6 a.m. no trace of them can be found. This periodicity was first observed by Dr. Manson, and has since been confirmed by Drs. Myers, Stephen Mackenzie and Lloyd Jones. What the reason of this is, has not yet been satisfactorily determined. Dr. Manson supposes that as day dawns they migrate to the blood-vessels of distant organs, like the lungs, where they cannot be easily detected; while Myers, reasoning on his observation that they become more languid and lethargic as morning approaches, thinks that they die out, and that a new swarm of embryos is produced by the females for the forthcoming night. However, the observation of Myers has not been confirmed, and it must be pointed out, as against his theory, that the parturition of the parent is not intermittent but continuous, and the enormous numbers in the blood can scarcely be considered as a single brood, even on the assumption that more than one fertile female is present in the system of the affected person. However, what determines their presence in the blood during the night-time has been clearly proved to be the resting condition of their human host. In a case which was imported from India to this country, and which came under the observation of Dr. Stephen Mackenzie, the patient changed his habits of life, and remained out of bed during the night, and slept during the day for a period of three weeks. The result was that the Filariæ were not found at all in the patient's blood during the night, but existed in immense quantities during the day-time. Dr. Manson has since confirmed this, and has also shown that if the general sleep of eight hours' duration be broken into two periods of four hours each, their numbers are sensibly diminished. Dr. Mackenzie has also shown that if the patient is awake and on the move during a thick and dark London fog, no specimens can be found in the blood.

Considering that they are chiefly embryos which are found in the human body, this periodicity is interesting in another relation. It has been shown by Dr. Manson that they have an intermediate host, and that intermediate host is a *nocturnal* species of mosquito, a species which has not been determined, but which can be recognised in the localities in which diseases from *Filaria sanguinis* occur by its dark brown colour and the absence of any markings on its abdomen, thorax, or legs.* Dr. Manson persuaded a Chinaman, who had embroyos of these Filariæ in his blood, to sleep in an outhouse which was infested with this special species of mosquito. He in the morning killed these mosquitos, which of course had been feeding upon the man, and found numbers of the embryos in their stomachs, and by a series of observations has shown that although some of them are digested yet others pierce the thorax of the mosquito and go through a series of changes in the surrounding tissues, which lead to a perfect fitness on the part of the parasite for an independent existence. This takes place in about four or five days. About the sixth or seventh day the mosquito, having laid her eggs on the surface of some pond, dies, her body becomes decomposed, and the Filariæ escape into the water, which after being drunk by some unsuspecting person they perforate the walls of his stomach and intestines and find their next resting-place in his lymphatics, just as the *Trichina spiralis* does in the muscles and the liver-fluke in the bile-ducts. The cycle now commences again; the adult female gives continuous birth to embryos in the lymphatics, and these, being no larger than the red corpuscles, make their way by the thoracic duct into the general blood stream, and so on.

It must not be supposed that persons who have Filariæ in their blood are always affected with symptoms of chyluria or elephantiasis arabum. Indeed it has been shown conclusively by Drs. Hall, Paterson, and others, that such is not the case, and that they may occur in the blood without giving rise to any external symptoms of their presence. But these two diseases are essentially due to obstructions in the flow of lymph throughout the body. Dr. Manson and several others have observed that sometimes ova instead of embryos escape from the vagina of the female, and it seems to be due to this abortive development that the diseases in question are produced; for these ova, not having the propulsive movements—the eel-like wrigglings before described—of the embryos cannot get through the narrow channels of the lymphatic glands, and so by their numbers dam back the lymph stream and stop its flow. They, in fact, act like, what is called in pathology, an embolus. As says Dr. Manson in his paper, which was read before the Pathological Society in 1880, " There will be a complete stoppage of the lymph in this particular vessel, as far back as the first anastomozing lymphatic. Along this the current will now pass, carrying with it other ova; these, in their turn, will

* The proboscis of this mosquito seems to be adapted in some inexplicable way for the purpose of extracting the embryos from the blood. The embryos become entangled in, or attracted to it, and a drop of blood taken from the proboscis of the mosquito contains a larger number than a drop of blood obtained from the person who has been bitten.

be arrested at the first gland they reach. And this process of embolism, stasis of lymph, diversion of current into anastomosis, will go on until the whole of the lymphatic glands, directly or indirectly connected with the vessel into which the parent parasite ejects her ova, are rendered impervious, provided the supply of ova is sufficient, kept up long enough, or renewed from time to time. The particular form of lymphatic disease, and the place affected, will depend on the position occupied by the parent worm, on the number of ova she ejects, on the frequency with which these miscarriages are repeated, and on the nature of the tissues involved, and individual peculiarities and accidents."

One great outcome of our knowledge of these Filariæ is the fact that these two diseases can be prevented by filtering the drinking water of the localities in which they are prevalent, but the filtering should be carried out on strict scientific principles. This is the more important since statistics reveal to us that one in every ten Chinamen is affected, and one in every twelve inhabitants of Bahia.

LUNAR AND TERRESTRIAL VOLCANOS.

By Rev. H. N. Hutchinson, B.A., F.G.S.

Readers of Knowledge will not have forgotten the Editor's interesting paper in the May number of last year on "The Great Bright Streaks which radiate from some of the larger Lunar Craters." It has been suggested to me that the question of the origin of these remarkable streaks might be discussed from the geological point of view, and that I should present some facts with regard to the lines of fracture and displacement among the stratified rocks of the Earth's crust which are known among geologists as "faults." Geological science has received valuable aid from astronomers, and possibly there are questions in Astronomy on which geologists might throw some light; at all events, it is a good thing occasionally that students of one science should endeavour to throw light on another. I only regret that the subject is not handled by one more deeply versed in lunar questions.

In my previous paper on "The Cause of Volcanic Action," I mentioned the connection between volcanos, mountain-chains, and lines of weakness in the Earth's crust, which are closely connected with lines of fracture (p. 106); and this would seem a fitting opportunity for turning our thoughts to those remarkable outbursts of volcanic action on a prodigious scale of which the Moon's numerous craters stand as silent yet speaking witnesses, and to inquire how far the cracks radiating from some of them may be compared with terrestrial cracks.

In Mr. Ranyard's paper we find a summary of the opinions put forward by different authorities on the subject of lunar streaks. "There are certainly seven such ray systems," he says, "all with craters at their centres, namely:—Tycho, Copernicus, Kepler, Byrgius, Anaxagoras, Aristarchus, and Olbers." Of these, Tycho is the most conspicuous example; its radiating streaks come out well in lunar photographs (see the illustrations, pp. 129 and 273, Vol. XIII.) The radiating streaks from Copernicus are well seen in the second photo, in the December number of 1890. Two of the longest from Tycho extend to a distance of over 1000 miles from the crater. Nichol thought, as Mr. Ranyard tell us, that they were composed of matter shot up from the interior of the Moon; and compares them to mineral veins or to "trap-dykes" (of basalt or other igneous rock), such as are known to pierce the sedimentary strata upon Earth.

Nasmyth's opinion was that the radiations "are cracks divergent from a central region of explosion, and filled up with molten matter from beneath." His experiment with a glass globe to illustrate this is described in the above paper (p. 130), also in Nasmyth and Carpenter's book on the Moon (1874, p. 134.) "Proctor seems to have favoured the trap-dyke theory. Neison, after carefully setting out the observed facts, refrains from advancing any theory." Young hesitates between this theory and the idea that they may be mere surface markings. Mr. Ranyard himself thinks "that they correspond to a series of radiating cracks, or faults, from which comparatively warm air issues charged with aqueous vapour, which is deposited as hoar-frost on either side of the vent."

Thus there seems to be a consensus of opinion that, in some way or other, the radiating streaks are due to cracks, and we can only conceive of such fractures as being due to a disruptive action, originated by the reaction of the interior of the Moon upon its outer crust. Taking so much for granted, we may pass on to the question of the nature of the disruptive force. Was it due—as Messrs. Nasmyth and Carpenter say—to the expansion of molten rocky matter below the Moon's surface on nearing the point of solidification? or was it originated by the cooling and consequent contraction of the body of the Moon which would leave the outer crust here and there unsupported, and hence this crust in settling down and endeavouring to adapt itself to a smaller surface below would undergo tangential strains and thrusts, which, it is easy to conceive, might result in a certain amount of fracturing? A simple illustration of this is afforded by the wrinkling of the skin of an apple as it dries. The soft pericarp below shrinks as it loses water, and so the skin has to settle down and accommodate itself to a smaller surface, and in doing so it must inevitably be wrinkled, or thrown into folds. This is a view which might perhaps commend itself to a geologist, for it is on a similar theory that geologists explain the great foldings which have produced terrestrial mountain chains, which latter are clearly connected with lines of weakness or fracture such as they suppose allowed rocky matter from below (charged with steam) to well up to the surface and so give rise to volcanic action. Volcanos, as we pointed out in our last paper, have a striking connection with mountain chains. On this view the folding, contortion and fracturing of strata, so conspicuous in mountains, is a secondary result of the secular refrigeration of our planet. Nothing short of this seems, at present, equal to the Titanic work of upheaval. At the same time the theory is not proved, and some authorities refuse to accept it.

Let us now turn to the Earth and see what Geology tells us about terrestrial cracks. These are of two kinds; first, there are the "faults," to which we have already referred; secondly, the "trap-dykes," which are very numerous in Scotland and northern England.

It may easily be conceived that the force which was sufficient to raise vast masses of solid rock of immense thickness from the bottom of the sea, where they were deposited, high into the air in order to form dry land, and, moreover, to bend them into great folds and contortions of all sizes, might also be sufficient to crack and break them through. Accordingly we find in the stratified series very frequent instances of cracks running through great thicknesses of rock, and obviously caused by disturbing force; sometimes they are mere fissures, but more frequently there is not only a severance but a displacement of the rocks that have been severed. Strata

once continuous are left at very different levels on opposite sides of the fissure. Hence the term "fault." Some of the "faults" known to geologists are not only of great horizontal length as traced along the surface, but of very considerable depth, and have produced enormous displacements. Thus the great Pennine "fault" of the north of England is known to be at least 55 miles long, and has a "throw" of 6-7000 feet, *i.e.*, the rocks on either side have been displaced to that extent. It was probably formed at some time during the upheaval of the Pennine range of hills, which runs north and south as the "fault" also does. The Tyndale "fault" has a throw of nearly 3000 feet, and it runs eastwards for about 50 miles. Fractures not unfrequently occur along the axes of great folds, such as we find in mountain chains, the strata having snapped under the great tension to which they were subjected during upheaval. Thus we find "faults" running parallel with some of the great mountain chains of the world; the Alps and Himalayas are cases in point.

This connection between great terrestrial cracks and important mountain ranges is only what might have been expected. The Unita Mountains of Wyoming and Utah consist of one broad flattened fold, with a displacement, in places where the uplift has been greatest, of 20,000 feet! If the lunar streaks under consideration are due to "faults," it is difficult to understand how the level on each side should be so little disturbed. As a general rule, the brightness of the lunar surface corresponds to the altitude of the ground. Mr. Ranyard says the rays do not correspond to lofty ridges, or even to ridges a few hundred feet in altitude, for no ridges casting shadows as the sun rises and sets can be detected as coincident with the streaks. It seems generally admitted that they do not correspond to lava-streams, for the rays run across mountains and plains, and even through the rings and cavities of old craters.

Believing the trap-dyke theory to be the most plausible explanation, we would like to ask whether, in spite of no shadows having yet been detected, the rays may not be due after all to *slight ridges* of igneous rock welling out in a viscous state from long cracks, and so catching a little more light than the surrounding parts of the lunar surface. Such ridges might be no more than 100 or 200 feet in height, and if their sides slope gradually it might be impossible to detect their shadows. We may also suppose they consist of some light-coloured trap-rock, such as felstone, and to be "weathered" by the lunar atmosphere, thus presenting a somewhat whitened surface. It is quite possible that the lunar trap-rocks may be of a highly siliceous nature, like "volcanic glass," also that they may have been considerably weathered and whitened by the action of great quantities of steam, now absorbed by the Moon, emitted in the last phases of lunar volcanic action. We know that steam can act chemically on glass, and turn it white. The lunar photograph in Mr. Ranyard's paper shows that the streaks are not nearly so bright as some mountains and craters, but this would easily be accounted for by the very great difference in height. Our idea is that the lunar mountain ranges are composed of volcanic rocks thrown up in some way from lines of fissure, and that the streaks are, as it were, attempts at lunar mountain ranges, which failed because for some reason the lava was not forced up in sufficient quantity. We rebel, for several reasons, against the idea of the lunar mountains being covered with snow. For instance, there is a great difference in the whiteness of different lunar mountains, which would be impossible if snow were the cause of the whiteness. But if they are composed of different kinds of trap-rock, it is extremely likely that they would weather differently, so that some might be whiter than others. Those, like basalt, of a more basic character (*i.e.* with more lime and magnesia), would be of a darker colour, while others, like felstone (which is acidic and contains much free silica), would be of a lighter hue.

In looking over the beautiful pictures in Messrs. Nasmyth and Carpenter's book, we notice another point which seems to favour this idea—namely, that short lines of mountains are so often seen in connection with lunar craters, sometimes roughly radiating from them, sometimes all more or less in one direction. We observe this especially in the pictures of Gassendi (the frontispiece), Copernicus, Archimedes, Aristotle and Eudoxus, Trisnecker, Plato, Mercator and Campanus, and also very plainly in the photo of Aristarchus and Herodotus. Again, the occurrence of craters in lines, in some cases, is another important fact tending to confirm this idea. (It will be remembered that terrestrial volcanos run very markedly in lines.) It may be well here to quote the authors above referred to. They say (p. 98): "We have upon the Moon evidence of volcanic eruptions being the final result of most extensive dislocations of surface, such as could only be produced by some widely diffused uplifting force. We allude to the frequent occurrence of chains and craters lying in a nearly straight line, and of craters situated at the converging point of visible lines of surface disturbance. Our map will exhibit many examples of both cases. An examination of the upper portion (the southern hemisphere of the Moon) will reveal abundant instances of the linear arrangement. Three, four, five, or even more crateral circles will be found to lie with their centres upon the same great-circle track; proving almost undoubtedly a connection between them, as far as the original disturbing force which produced them is concerned. Again, in the craters Tycho, Copernicus, Kepler and Proclus, we see instances of the situation of a volcanic outburst at an obvious focus of disturbance."

On this theory, the dark linear markings on the Moon, known as "hills" or "clefts," are probably cracks up which, for some reason, the molten matter only welled-up to some point below the surface. Perhaps they formed later than other terrestrial features, after the volcanic fires had died out, and when the linear surface was losing its old heat rapidly and therefore cracking as it contracted on cooling.

It must be confessed that there is little to be said in favour of the view that the lunar streaks have been produced in a similar way to terrestrial "faults," for several reasons: First—the mountains of the Moon, as far as we can see, are different to terrestrial mountains, and seem to be entirely volcanic, whereas our mountains are mostly due to the upheaving and folding of sedimentary strata; their present outlines being the result of long-continued atmospheric denudation. Secondly—it seems to me impossible, in the present state of our knowledge, to say whether stratified rocks are present on the lunar surface. If at one time there were seas, and an atmosphere at all like ours, "denudation" must certainly have taken place, and that would involve the accumulation of marine sedimentary deposits. Many believe that there is evidence of stratification and even of tilted strata in the lunar Apennines; but if this is the case, I should prefer to consider such strata as purely volcanic, viz., lava and ashes. Thirdly—terrestrial "faults" are very sharp lines of division, like the cracks which form in a sheet of ice after continued skating, so that we could not expect to see them.

One word in conclusion about "trap-dykes." These are veins of eruptive rock (basalt, &c.) filling up vertical

or highly inclined fissures, and are so named on account of their resemblance to walls (*Scottice*, dykes). When the surrounding rock has decayed, the dykes may be seen projecting above ground exactly like walls. Sometimes the eruptive rock has followed the course of a "fault"; but in Scotland, at least, the vast majority of dykes rise along ordinary fissures which, having caused no displacement, cannot be considered as "faults." On the contrary, the dykes may be traced undeflected across some of the largest "faults." Dykes differ from veins in the greater parallelism of their sides, their verticality, and greater general regularity. Usually a dyke cannot be traced far, but the well-known Cleveland Dyke, in the north of England, runs for at least 60 miles, cutting through various "formations" till it reaches the Yorkshire coast, 200 miles or more from the sheets of Miocene trap-rock with which it is probably connected. The south-western half of Scotland, and the northern parts of England are ribbed across with thousands of dykes which seem to be connected with the volcanic chain of the inner Hebrides (of Tertiary age). The fissures through which such dykes forced their way were not made by the molten matter itself, but more probably were the result of violent explosions and earthquakes proceeding from a region of volcanic action.

I must now conclude this paper, leaving the reader to judge if I am warranted in applying the trap-dyke theory to the lunar streaks. It certainly harmonizes lunar and terrestrial phenomena, and suggests a close connection between radiating streaks, chains of lunar volcanos, mountain ranges, and ridges or lines of hills near the volcanos.

Remarks by A. C. Ranyard.

If the reader will turn to the photographs of the Moon, published in Knowledge for May, 1890, and October, 1889, he will see that the rays or streaks have not sharply defined edges as they presumably would have if they were trap-dykes. The rays vary in breadth, many being from twenty to thirty miles broad, with very soft nebulous edges. The whiteness of the rays in some cases may be seen to degrade gradually from a narrow, sinuous, bright band which runs along their centres—see, for example, the two rays from Tycho that run across the Mare Nubium, shown in the plate published in the May number for 1890. The rays seem in no way to interfere with the forms of the craters and irregularities of the lunar surface, as we should expect to find them interfering if they corresponded to a wall of injected rock either harder or softer than the surrounding material. A good instance of a broad ray passing over craters and rough ground without affecting the forms of the craters and mountains is shown in photograph No. 1, plate No. 1, in the October number for 1889, where a strikingly bright ray radiating from Tycho passes across the rough ground to the south of the Mare Nectaris and then across the plain and onward.

Lava streams and volcanic regions on the earth are generally dark as compared with the surrounding rocks, but the light-reflecting character of these rays cannot be accounted for unless they are capable of reflecting more light than light sandstone, or even than chalk. For the light-reflecting power of the Moon, taken as a whole, about corresponds to that of light sandstone. See the often quoted observation of Sir John Herschel, who compared the light of the nearly full Moon with that reflected from Table Mountain at the Cape. Everyone is familiar with the whitish appearance of the Moon as seen in the day-time. It appears like a small whitish cloud.

There are many large dark areas upon the Moon, consequently the brighter parts must be relatively white as compared with light sandstone. It is true that the summits of lunar mountains and craters differ greatly as to their whiteness, but few terrestrial mountains are wholly covered with snow, and, as seen from a distance, their whiteness would depend upon the amount of rock surface and shadow intermixed with the snow. The Moon, as a whole, reflects a little less than a quarter of the light reflected by fresh fallen snow. My argument is that the brighter patches and rays are so bright as compared with the rest of the Moon's surface that their whiteness cannot differ greatly from the whiteness of snow.

THE CHEMISTRY OF THE DAIRY.

By Vaughan Cornish, B.Sc., F.C.S.

IT is often felt as a disappointment by persons who have been at some pains to acquire a knowledge of the principles of chemistry, that the chemistry of the breakfast table remains still beyond their ken. Common salt presents no difficulty, but what are mustard and pepper, sugar, milk and butter? Many a chemist has had his breakfast spoilt by being called upon to explain the composition of these things when he would rather be availing himself of their nutritive properties. The "Professor at the Breakfast Table" may sometimes indulge the didactic vein, but only in a moment of unusual rashness will the professor attempt an untechnical exposition of the constitution of organic bodies. The reason is not far to seek. The number of organic substances is very large, being reckoned, indeed, by thousands. The great majority of these consist of carbon and hydrogen, of carbon, hydrogen, and oxygen, or of these three elements together with nitrogen. A mere statement of the elements contained in the substance gives practically no information as to its nature. Each chemical substance is made up of a number of small parts, the *molecules*. The properties of the substance are determined principally by the properties of the molecules. The molecules of organic substances are differentiated from one another, chiefly by the number of atoms in the molecule, and by the mode of arrangement of these atoms, rather than by the nature of the atoms themselves. The connection between the arrangement of the atoms and the properties of a substance is subtle and intricate, and the experiments required for the discovery of the mode of arrangement of the atoms are complicated and difficult to follow. There is no royal road to this branch of knowledge; a general grasp of organic chemistry can only be gained through the laborious study of detail. It is possible, nevertheless, to impart a certain amount of information concerning the chemistry of foods without demanding this knowledge of details. It is true that the acquaintance which is thus gained is far from being satisfying to the enquiring mind, but it is nevertheless thus far satisfactory that it has a definite practical value.

The present article, within the limits we have indicated, deals with the chemistry of milk and of the food-stuffs prepared from it. Milk may be described as an emulsion, its opacity being due to the dissemination throughout its bulk of a great number of small globules of fat. This fat swims in a watery fluid, not pure water but an aqueous solution of caseine, milk sugar, and a small amount of inorganic matter consisting chiefly of common salt and phosphate of lime. In the study of milk, cream, butter

and cheese we are principally concerned with the various proportions in which these articles contain the three constituents, fat, caseine, and milk sugar. Our mode of treatment of the subject precludes us from attempting a detailed explanation of the chemical nature of each of these ingredients; we merely draw attention to the fact that fats and sugars possess distinct and valuable nutritive properties (chiefly as fattening and warming diet), whilst caseine, which is the only one of the three containing the element nitrogen (which constitutes about 15 per cent. of the caseine) helps to form tissue, its presence in cheese giving that article its value as a substitute for meat diet. The composition of the milk of cows only varies within somewhat narrow limits. Change of diet affects rather the quantity than the composition of the secretion, milk in this respect resembling the blood rather than certain other animal fluids. It is true that the diet affects the flavour (as in the case of a turnip flavour from swedes if eaten shortly before milking time), but this is apparently due to the presence of a very small quantity of a strongly-tasting material, the percentage composition of the milk being practically unaffected. Below are given representative analyses of—

(1) Ordinary country milk.

(2) Of town milk from stall-fed cows, which is generally somewhat richer in fat.

	Country Milk.	Town (stall-fed) Milk.
Water ...	87·55 %	85·94 %
Fat ...	3·09	4·00
Caseine ...	4·01	5·01
Milk sugar ...	4·63	4·31
Ash ...	·72	·74
	100·00	100·00

We have said that the composition of cows' milk varies, though only within somewhat narrow limits. Rich milk contains more fat, poor milk more water; the dissolved substances (caseine, milk sugar, and the inorganic substances), which are often referred to as the *milk solids not fat* constitute a nearly constant quantity. The determination of the milk solids not fat affords a means of ascertaining if the milk has been *sophisticated*, that is to say, has undergone artificial alteration of its composition. Thus a milk with a somewhat high percentage of water would pass as a naturally poor milk if the solids not fat were in the usual proportion to the total weight of the milk, but if the amount of these solids is too low the conclusion can be drawn that the milk has been watered. Skimming the cream or fat from the surface of the milk would make the percentage of solids not fat too high. It is true that it would be possible to combine the two processes of skimming and watering so as to leave unaltered the percentage of solids not fat, but in this case the ratio of water to fat would be greater than is admitted by the known range of variation in the composition of the natural milk. This device of combined skimming and watering is said to be sometimes resorted to in order to baffle the inspector and his lactometer. The specific gravity of milk is about 1·03 (water being taken as unity). The fat is lighter than water, therefore skimming raises the specific gravity. Ordinary well water is lighter than milk (owing to the presence of the solids in solution in the watery fluid of the milk), hence watering lowers the specific gravity. Though the lactometer—which indicates the density by the depth to which it sinks—is devised to detect either mode of sophistication, yet a skilful combination of the two will baffle the instrument. As we have shown, however, analysis is capable by an indirect method of detecting this mode of sophistication. It is, nevertheless, unfortunate that there is no *direct* test known by which added water can be discriminated from that of the natural milk. It is probable that the adulteration of milk with impure water has sometimes resulted in the propagation of disease.

When milk is left to stand, the globules of fat, being lighter than the liquid in which they float, gradually rise to the surface, a layer of cream being formed. The richness of the cream thus produced varies greatly, the percentage of fat being sometimes less than 20, sometimes more than 40. The watery fluid of the cream has nearly the same composition as that of ordinary milk, and by the determination of the proportion of water to milk solids not fat the analyst is enabled to judge if the article has been treated by watering.

In cream the globules of fat are more closely aggregated than in milk, but when the cream is subjected to prolonged agitation, as is done in the churn, the globules actually cohere, and a solid mass separates from the butter-milk, which consists principally of water, caseine, and milk-sugar. The salt, which is added as a preservative, and for flavouring purposes, passes largely into the butter-milk, that which remains in the butter being kept in solution by the water present. Good butter usually contains about 14 per cent. of water, 2 per cent. of salt, and a very small quantity of caseine, the remainder, or more than 80 per cent., being fat. Its value as a food depends on the proportion of fat, but the importance of freeing the butter as much as possible from water arises also from the circumstance that water in an undue proportion not only lessens the nutritive value but prevents the butter from keeping. Although rich butter consists principally of milk fat, the fat by itself would prove unpalatable.

Fats other than milk fat, chiefly the fat of meat, are now largely employed for the preparation of a substitute for butter. They possess some of the valuable qualities of milk fat, but are inferior in flavour, and less easily digested. Margarine is sometimes made wholly from these fats, whilst the more expensive kinds contain milk fat, sometimes in quantity equal to that of the foreign fats. Formerly the detection of foreign fats in butter could not be made with certainty, but as the practice of adulterating butter in this way became more general, new methods of analysis were elaborated, and now the detection of foreign fats can be made readily and with certainty. Any material containing an admixture of foreign fats is, legally, margarine, and its exposure for sale without the well-known label is punishable by fine. The examination of "reputed butter" now forms a considerable part of the public analyst's work. A usual method of procedure is to determine, by a quick process, the specific gravity of the melted fat. If the specific gravity is below that of butter fat, a chemical analysis is made. The principal tests are those depending on the fact that milk fat yields about ten times as much butyric acid as other fats, and that the ordinary margarine fats yield a larger proportion of the so-called *unsaturated* acids. These have the power of combining with iodine, and their presence may be detected by the *iodine-absorption* test, which consists in determining the change of strength which takes place in a standard iodine solution when left in contact with the material.

In the process of butter-making, as we have seen, almost all the caseine and the milk sugar are left in the butter-milk. In Germany, milk sugar is extracted from butter-milk for the purpose of adding it to ordinary cows' milk intended as food for infants. In this way a milk is obtained which approximates closely to the natural food of children, which contains a larger proportion of sugar than the milk of the dairy.

In the manufacture of cheese the nitrogenous material of milk (caseine) is thrown out of solution in the solid form by the action of *rennet* (an infusion from the stomach of the calf), whilst the greater part of the milk sugar remains in solution in the whey. Cheese contains also inorganic matter and a variable proportion of fat. A large proportion of fat imparts richness to cheese, the richest cheeses, such as Stilton, being made from milk with added cream. There are also cheeses made from ordinary milk, or "whole milk" cheeses, and cheaper kinds made from skim milk. In these different varieties the proportion of fat varies from 20 to more than 40 per cent., the proportions of caseine and of water having about the same range. It sometimes happens that margarine fats are used in making cheese, as an economical method of imparting "richness." The detection of the fraud may be made by separating the fat and subjecting it to the same tests as in the analysis of margarine.

ON THE FERTILIZATION OF TWO COMMON BRITISH ORCHIDS.

By J. Pentland Smith, M.A., B.Sc., &c., Lecturer on Botany, Horticultural College, Swanley.

For some years Orchids have been in high favour with florists and that section of the flower-loving public who can indulge in the luxury of a hothouse. Most of the quaint and beautiful specimens one sees have their home in the tropics, and are epiphytes (that is, they obtain the whole of their food from the air). We will content ourselves with the examination of two plebeian members of the family that are to be found in plenty in England, and are of terrestrial growth. They are quite as interesting as their exotic brethren. The first of these, the early purple Orchis (*Orchis mascula*), a month ago was flowering in our woods. The first thing that strikes the casual observer on examining these Orchid flowers is the curious shapes they assume, a circumstance that has led to the application to them of such names as Butterfly Orchid, Frog Orchid, and Bee Orchid, these names indicating their supposed resemblances to living creatures. The appearance of the early purple Orchis is no less striking. This name has been applied to it on account of the reddish-purple flowers that make their first appearance during the month of April. It continues flowering until July, its flowers are grouped in spikes, and are occasionally almost white. They arise from the axil of a coloured bract.

In plants with net-veined foliage leaves, the outer covering of the flower—the *calyx*—is composed, as a rule, of green-coloured modified leaves (*sepals*). But the Orchid ranks amongst the Monocotyledons—plants with parallel veined foliage leaves, and coloured sepals—which are thus often indistinguishable from the inner whorl of enveloping organs (the *petals*). Fixing our attention on a single flower, and holding the spike so as to bring the flower next us and the stalk or *axis* from which it springs away from us, we notice that one of the three sepals lies next the axis, and is consequently further away from the body of the spectator than the other parts of the flower, and is superior in position to these; it is thus said to be posterior or superior, while the other two are termed the lateral sepals. Alternating in position with these organs are three petals. The two lateral ones are of small size; the third, or odd one, is anterior or inferior in position, and is abnormally developed into a broad, expanded, purple-spotted lip, or three lobes. The middle lobe is longer than the others and is notched at the tip. This petal is termed the *labellum* (Fig. 1. 1). An opening near its point

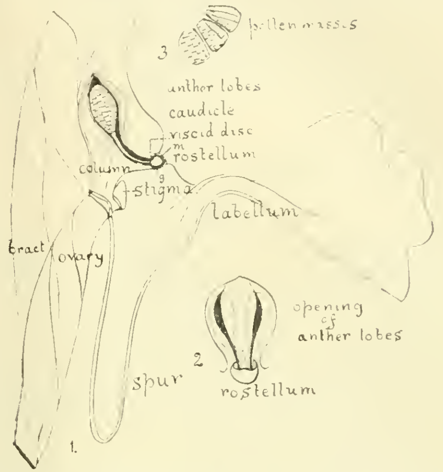


Fig. I. 1. Semi-diagrammatic view of the flower of *Orchis maculata*, magnified (which agrees practically in structure and in method of fertilization with *Orchis mascula*). The ovary is made to shine through the bract; the labellum is cut through the middle, and the left anther-lobe is also seen in section. The left petal is removed.

2. Front view of stamen and rostellum.

3. Group of pollen-masses.

of origin leads into the canal of a stout pouch or spur, with which it is furnished. Situated opposite the posterior sepal there is a shield-shaped body, at whose base is a small bulbous swelling, the *rostellum* (Fig. I., 1, 2). The latter more or less obstructs the entrance to the pouch of the labellum which it overhangs. The sides of the shield are swollen; the swollen portions (Fig. I., 2) narrow as they approach the rostellum, and each one is slit from top to bottom. A closer examination of these will amply repay us for the time so spent. First, then, we will take a fully-expanded flower, and insert the end of a well-sharpened lead-pencil into the spur of the anterior petal. If withdrawn immediately, two small Indian club-shaped bodies (Fig. 1., 1) will probably be found adhering to it. We say "probably," because these bodies may have been removed already. They are simply masses of pollen (Fig. I., 3) held together by elastic threads. The union of the threads forms the handle of the club, and is called the *caudicle* or little stalk; the caudicle rests on a small plate of tissue termed the *disc*. The whole structure is called a *pollinium*. Further examination of the swellings of the shield shows that their cavities are now empty; the pollinia formerly occupied them.

In an ordinary flower, the pollen grains are contained in two lobes at the summit of the stamens, called the anther-lobes. When these open the pollen grains fall out as a fine powder, as they are more or less free from one another, but in Orchids the contents of each anther are shed *en masse* in the shape of the pollinia described above. Each swelling of the shield is thus an anther-lobe, and the whole shield is a *stamen*. The tissue between the lobes is the connective, the upper portion of the stalk or filament of the stamen. The great separation of the lobes from one another is not unique. It is frequent in other kinds

of flowers—*e.g.*, *Berberis vulgaris*, the Barberry; *Salvia*, the Sage.

The little discs to which the caudicles are attached are sticky on the under surface. The viscid material enables them to adhere to the proboscis or head of any insect with which they come in contact. The filament of the stamen has not yet been seen by us—in fact, search for it would be in vain, as it has united with the pistillate or female portion of the flower to form the *column*. It is evident, then, that only one stamen is present in the flower. A vertical section through the rostellum of another flower which has not been robbed of its pollinia reveals the source of the viscid material of the disc, and also of the discs themselves, for the rostellum is a thin membrane (Fig. I., 1 *m.*) whose interior is lined with a granular fluid (Fig. I., 1 *g.*) that surrounds two balls of viscid matter, only one of which is seen in Fig. I., 1. Each ball is attached to a circular piece of thin membrane, thinner than the rest of the membrane of the rostellum, but confluent with it. As is evident from the figure, the discs are developed towards the back of the flower and the pollinium assumes a curved position in its case.

Situated beneath the rostellum are two protruding sticky patches almost united to one another. They are the stigmatic surfaces (Fig. I., 1). The flower is supported on a thick twisted stalk. Fig. III., 4, is a section of the similar stalk of Habenaria, the Orchid we are next to consider. It is lined with three longitudinal rows of ovules, and so it is the ovary of the flower. It is important to note that it is twisted. The style (that portion of the pistil that is generally elongated and bears the stigma on its summit) is here very short, forming part of the column, as already noted.

A wonderful mechanism comes into play in connection with the removal of the viscid discs. Whenever an insect touches the rostellum, the delicate membrane ruptures before and behind, so as to leave the discs free. At the same instant it springs downwards and exposes the balls of sticky matter, which then come in contact with the animal's body. The manner in which fertilization is accomplished is as follows:—An insect alights on the labellum, and in endeavouring to push its proboscis into the nectary to obtain honey, it infallibly knocks its head against the irritable rostellum. The mechanism already described then comes into action, and the insect leaves the flower with one or both pollinia firmly affixed to its head. It may repeat the process on other flowers of the same spike, so that when it flies off from it many pollinia may be attached to its body. Darwin, to whom we are chiefly indebted for our knowledge of the processes of Orchid pollination, says that he found ten to sixteen pollinia attached to the bodies of live bees that had been visiting an ally, *Orchis morio*.

Bees only spend three or four seconds on each flower; hence it is evident that the sticky material of the discs cannot take long to harden, and this is so. It is also quite apparent that unless the pollinia changed their position on the insect's head that insertion of the proboscis into the nectary of another flower would simply lodge the pollinia relatively in their old position. To prevent this, a marvellous contrivance is exhibited. The small viscid disc has such power of contraction that it causes the pollinium to move in a forward direction through an angle of 90°, thus bringing it into a position that ensures its impinging on the stigma of another flower visited by the bee. It must be understood that the discs are firmly fastened to the insect's head. Were it not so, in moving, they might assume a lateral direction, which would prevent them performing the act of pollination. The cement sets hard, according to Müller, in from three to five seconds when exposed to the air, and this is the time occupied by the bee in visiting a single flower. About forty seconds, as a rule, elapse before the pollinia bend forward. A bee, as a rule, spends twenty-five seconds on a single spike; thus, fertilization with pollen from the same inflorescence is obviated. The time occupied in flying to another spike gives the pollinia the opportunity of assuming the position requisite for the performance of the act of pollination.

It frequently happens that only one pollinium is removed at a time; hence, unless some special contrivance were provided, the other pollinium would be useless owing to the exposure of its cement to the air by the lowering of the membrane of the rostellum. This is obviated by the power inherent in this membrane of springing back to its place immediately a pollinium has been removed.

Müller records an interesting study he made of the cross-fertilization of this Orchid. "On May 6th, 1869, I and my son Hermann at length succeeded in observing humble-bees fertilizing the flowers of Orchis upon Stromberg Hill. As we lay upon the turf, which was overgrown with *Orchis mascula*, we saw a humble-bee (apparently *Bombus terrestris*) alight, close beside us, on the base of a spike of that plant. It thrust its head into a flower, and drew it out, after about four seconds, with the pollinia attached to it. It repeated the same operation on two more flowers. After withdrawing its head from the third, it paused, and tried without success to free itself from the pollinia, which were cemented firmly to the front of the head. Climbing a little further up the spike, it thrust its head into a fourth flower. . . . Of ninety-seven humble-bees which we caught on that day on Stromberg Hill, thirty-two bore pollen-masses of Orchids."

Although one repeatedly examines the nectaries of *Orchis mascula*, one always finds them destitute of nectar. This was a puzzling circumstance to Darwin. He could not account for the continued visits of insects to these flowers unless by the fact that they themselves benefited by it. In fact, so strongly convinced was Sprengel that no nectar was produced under any circumstance, that he called them sham-nectaries. Darwin, however, could not believe that insects would allow themselves to be so systematically duped. But not a drop of nectar was revealed even by microscopic examination. At last he found a clue. The spur of the labellum has a comparatively thick wall, and its inner membrane is delicate; moreover, the juicy nature of its contents is very evident. In Habenaria there is a copious supply of nectar, and the wall of the spur is thin. Darwin observed that bees which visited the flowers of *Orchis morio* "remained for some time with their proboscides inserted into the dry nectaries, and (he) distinctly saw this organ in constant movement. (He) observed the same fact with Empis in the case of *Orchis maculata*, and on afterwards opening several of the nectaries (he) occasionally detected minute brown specks, due as (he) believed to the punctures made some time before by these flies." This then is the solution of the problem—the insect bites with its mandibles the fine inner membrane of the wall of the spur, and sucks out with its proboscis the fluid contained therein.

It will be remembered that the pollinia cannot be affixed to the head of the insect visitor unless the cement of the disc has hardened. This requires about three or four seconds, the time spent by the insect in piercing the wall of the nectary. We see then how beautifully, even to the minutest detail, this flower has been modified in order to ensure its cross-fertilization.

For its intrinsic interest and as affording a contrast to the preceding, we will examine the structure and mode

CATTLEYA MOSSIÆ.

This epiphytic Orchid is a native of La Guayra, on the coast of Venezuela. It derives its nourishment wholly from the air, clinging to other objects merely for support. The flowers are very large and fragrant. The photograph is on half the scale of Nature.

of fertilization of *Habenaria chlorantha*, the Butterfly Orchis. It is quite a common form, flowering during June and July in meadows and on heaths. It is noted for its fragrance and for its pure white, but generally greenish-yellow flower (χλωρος, green, and ανθος, a flower). The spur is very long, at least twice the length of the ovary. The labellum is strap-shaped; hence the name *Habenaria* (*habena*, a thong) according to some authors, although Hooker says the etymology is doubtful.

The connective is largely developed, so that the two anther-lobes are very much separated, especially at the base (Fig. II.). The discs of the pollinia are thus far apart. The viscid matter is not enclosed in a pouch as in *Orchis mascula*, but is free on the under surface of the discs which face one another (Fig. II. *d*.). These occupy a position anterior to the two united stigmas situated beneath (Fig. II.). Another curious arrangement is seen here.

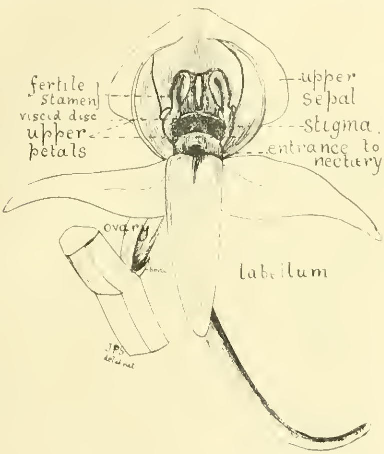


Fig. II.—Front view of flower of *Habenaria chlorantha* (Butterfly Orchis).

Instead of the caudicle being attached at once to the disc, it is hinged to a small process that arises perpendicularly from the upper surface of that organ, and is called the *pedicel*. The pollinia lie far back in their cells, so that the caudicles are slightly bent. In their natural position each caudicle is at right angles to the pedicel, and consequently parallel to the viscid disc (Fig. III., 1, 2). The nectary is generally two-thirds full of nectar, and so is visited frequently by insects. The fragrance of the flowers, and their light colouration, admirably fit them for the visits of insects that fly by night. These are in this case moths. It frequently happens that, on account of the distance between the discs, only one pollinium is removed at a time. They are often found adhering to the eye of the insect. The viscid matter does not set hard immediately, but is of such a nature as to fix the pollinia firmly to the head of the intruder without setting.

Fig. III.—*Habenaria chlorantha*. The parts are as noted in the figures.

It is clear that unless some movement of the pollinia takes place after their fixation to the insect's head, that fertilization will not be effected. The pedicel performs the needful act. It contracts along one side, and at the same time moves through an angle of nearly 90°, dragging the pollinia inwards and downwards, and in the exact position to strike against the stigma when next an insect visits a flower of the same species.

As the viscid material does not require to be set hard, but performs its office immediately, there is no puncturing of a nectary required to detain an insect; instead, there is a free supply of nectar.

The structure of the Orchid flower is quite anomalous, but it can be reduced to the normal type, though it required the genius of Darwin to work it out. The parts of a flower are generally developed in whorls, and the members of one whorl alternate, as a rule, with those of the adjacent whorls. Exceptions to this rule can generally be accounted for by displacements that have occurred during the development of the floral parts. The significance of the organs of the Orchid are more difficult to determine. Darwin accomplished the task by counting the groups of bundles of spiral vessels that proceeded from the ovary. These are in part the constituents of the *veins* of a leaf. Their presence would denote the presence of a leaf or modified leaf at an early stage in the development of the flower, as they are generally the first differentiation exhibited in the tissues of a growing mass of cells of a higher plant.

Fig. IV. is the result of his labours in this direction. In *Orchis mascula* and *Habenaria chlorantha*, and in all Orchids, with the exception of the *Cypripediums*, there is only one fertile stamen—the posterior one of the outer whorl. The other two belonging to this whorl have become united to the anterior petal to form the labellum. Of the three stamens of the inner whorl none are represented in the Orchids whose fertilization we have described. In *Cypripedium* the two lateral stamens of the inner whorl are the fertile ones, while the posterior stamen of the outer whorl forms a large head which projects above them. When the third stamen of the inner whorl is present, it unites with the anterior portion of the column, and so acts as a support.

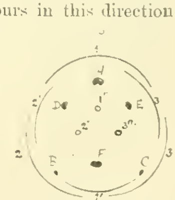


Fig. IV. — Ground plan of typical Orchid flower. 1, 2, 3, sepals, 1 is the posterior sepal; 1′, 2′, 3′, petals, 1′ is the anterior petal; A, B, C, outer whorl of stamens. B and C are united to the anterior petal and so help to form the labellum; A is the fertile stamen in all Orchids with the exception of *Cypripedium*; D, E, F, stamens of inner whorl, none of which are present in *Orchis mascula* and *Habenaria chlorantha*—in *Cypripedium* D and E are the fertile stamens; 1″, 2″, 3″, stigmas; 1′ is modified to form the rostellum.

There are three stigmas corresponding to the three groups of ovules in the ovary. But only two of the stigmas act as such; the posterior one is modified to form the rostellum, whose viscid matter has been formed in the cells of which it was originally composed, and which have afterwards broken down.

Another point of interest remains to be noted in regard to the position of the floral parts. The ovary is twisted in such a way as to cause the truly anterior portions of the flower to hold a posterior position and *vice versâ*, but in the foregoing description, and in Fig. IV., no account has been taken of this. The labellum, for instance, has been spoken of as the anterior petal and two anterior stamens of the outer whorl united, whereas the adjective posterior would be the correct one to use.

SWIMMING ANIMALS.

By R. Lydekker, B.A., Cantab.

In our last article we discussed the various structural modifications by means of which the members of different groups of animals are enabled to fly, or, in other words, to swim in the aërial ocean. From the observations recorded there, it is evident that all the creatures adapted for this peculiar mode of life have been specially modified for that purpose; flight thus always being a power which has been specially acquired, and not one which was an original attribute of any group of animals.

It is our purpose in the present essay to notice in a somewhat similar manner the various adaptations of the structure of certain animals whereby they are enabled to swim in the denser medium of water. And here we shall find that while there is conclusive evidence to show that in many instances this power is an acquired one, yet there are others which lead to the belief that in certain groups it is a primitive function. Some clue as to the groups in which this power of swimming is an acquired one, and those in which it is a primitive one, is afforded by the different modes in which aquatic animals breathe. Thus in fishes the air necessary to oxygenate the blood is obtained from that dissolved in the water itself by its constant passage over those peculiar comb-like organs, highly charged with blood, known as gills; such animals having, therefore, no occasion to come to the surface of the water to breathe. In other animals, however, such as Whales and Grampus (Fig. 1), atmospheric air is breathed directly by means of lungs, necessitating visits at longer or shorter intervals to the surface, and it is in such instances that we may safely infer that the adaptation to an aquatic life has been gradually developed from ancestors whose normal habits were terrestrial, since otherwise the gills would never have been lost. That animals whose original mode of life was a purely aquatic one have tended in some cases to assume a terrestrial existence is proved by the case of the Common Frog, which commences life as a gill-breathing, swimming creature, which is to all intents and purposes a fish, and ends by being an air-breathing reptile, as much at home on land as in the water, although retaining the power of swimming. On the other hand, the Seals and Otters show us how an originally terrestrial type of animal has become adapted to pass a large part of its time in the water, which has become its natural element.

The term "Swimming Animals" is, of course, a very wide one, since a considerable proportion of animals whose normal habits are terrestrial can, on occasion, swim with more or less facility. Our application of the term will, however, in the main be restricted to those creatures which pass a considerable amount, or the whole of their time in the water, and which have accordingly been more or less specially modified for that kind of life. Again, in many groups of purely aquatic animals, it is sometimes difficult to say which are true swimmers; a certain number leading an active life when young, and becoming more or less complete fixtures in adult life. We shall commence our survey with the Invertebrate Animals, treating them, however, in a somewhat briefer manner than the Vertebrates, and alluding only to some of the more striking adaptations of certain parts of the body for the purpose of swimming.

All are familiar with those disc-like masses of pellucid gelatinous matter so often thrown up on our sea-beaches, and popularly known as Jelly-Fishes; but to see them in their full beauty we should look down from the bows of a large vessel traversing the warmer oceans. There they may be seen in countless multitudes, extending as far down in the water as the eye can penetrate, and by daylight presenting various tints of pink and purple, while by night they are often phosphorescent. These Medusæ, as they are technically called, are gelatinous creatures shaped somewhat like an umbrella, the "handle" being formed by a mass of thick tentacles hanging down in the water. They swim by the alternate contraction and expansion of the "umbrella" or bell, the diameter of which may considerably exceed a foot. Medusæ belong

Fig. 1.—The Common Grampus, or Killer Whale.

to that great group of animals known as Zoophytes, which includes the Polypes, Sea-Anemones, and Corals. They afford an example of the so-called "alternation of generations"; being themselves developed by the division of a fixed polype into a number of saucer-like sections, which become free and swim away, and in turn lay eggs, again developing into fixed Polypes, like the original parent.

Our next illustration is taken from the Crustaceans, in which the Lobsters and some of the Crabs are expert swimmers. In the Lobster and Cray-Fishes, where the tail is long, and furnished with five hinged and paddle-like plates, the most rapid motions in the water are effected by suddenly bending the tail beneath the body, and thus driving the creature forcibly backwards by the recoil of the water. Prawns and Shrimps have a similar mode of swimming; but those Crabs which, like the "Fiddlers," are free swimmers have the terminal joints of the fifth pair of legs (and sometimes also those of the three next pairs) developed into flat paddles fringed with hairs. These claws are thus quite different from the pointed claws of the common Shore-Crab. Since Crabs and Lobsters breathe by means of gills, they may be safely regarded as primitive swimmers; those species which, like the Land-Crab, are terrestrial having acquired this habit, and thus having to put up with the inconvenience of keeping their gills constantly moist. We cannot take leave of the Crustaceans without mentioning the Barnacles, as represented by the common Acorn-Barnacle covering the rocks on our coasts, and the Stalked-Barnacle which is more commonly found on the bottoms of ships. In their young state these curious creatures are free-swimming Crustaceans, but after a time, becoming tired of a roving life, fix themselves on their backs by the front of their heads to some solid object, and then develop their well-known shells; the feather-like fan which protrudes from the aperture of these shells being the greatly modified legs, now acting as feelers for the purpose of capturing food. What induced the strange belief that the Stalked-Barnacles underwent a further metamorphosis to appear as Bernacle-Geese, passes ordinary comprehension.

Passing on to the Arachnids (Spiders and Scorpions) and Insects, we find that these creatures, whether aquatic or terrestrial, breathe atmospheric air by means of a system of tubes known as tracheæ, and we are accordingly led to conclude that such of them as are adapted to an aquatic life have acquired this habit. This is especially well shown by the instance of the Water-Spider, which, while agreeing in structure with other spiders, has the limbs fringed and somewhat flattened for swimming, and is in the habit, when diving in the water, of carrying down with it a bubble of air clinging to the hairs of the abdomen.

Among the Insects, the larvæ of many groups in which the perfect animals inhabit the air, such as the Dragon-Flies, May-Flies, and Gnats, are aquatic. Whereas, however, the larvæ of the two former groups are not swimmers, and, therefore, do not come within the scope of the present article, those of the Gnats are endowed in great perfection with the power of swimming. With their large heads and their tapering bodies, these ugly larvæ are probably familiar to most of us, swimming about in ponds and tanks with great agility by a sudden jerking motion of the body, or at intervals suspending themselves head downwards at the surface of the water for the purpose of breathing through a tube situated in the tail. Other insects are aquatic in the adult state. Some of the commonest British examples are the Water-Scorpion (*Nepa*) and Water-Boatman (*Notonecta*), both belonging to the order Rhynchota. These swim by means of the hind legs, which are, however, scarcely fringed in the former, although markedly so in the latter. The Water-Scorpion has two tail-like organs at the end of the body, which, when put in opposition, form a tube through which the creature can breathe without coming quite to the surface. The Water-Boatman, as its scientific name implies, has the curious habit of swimming on its back; when at rest for the purpose of taking in a fresh supply of air the long hind legs are extended nearly at right angles to the body, and thus recall a boatman resting on his oars.

The remaining aquatic insects are the Water-Beetles (Coleoptera), of which there are several families, in all of which both the larvæ and adults are aquatic, although the pupæ are quiescent and lie hidden in holes in the ground. The Water-Beetles are easily recognized by their oval, flat, and boat-like form; some of the species attaining a large size. Most of them swim entirely by the aid of their hind legs, which are greatly enlarged, flattened, and fringed. In the curious little "Whirligig" Beetles (*Gyrinus*), which are so often seen performing their mazy evolutions on the surfaces of ponds and rivers, the reverse of this arrangement obtains, the front pair of legs being enormously elongated, and the second and third pairs very short and paddle-like. The forward motion of these beetles is produced by these short paddles, while the curves are formed by the long fore limbs, which are darted out first from one side and then from the other, so as to change the direction of the body.

The last Invertebrate group we have to mention is the large one of the Molluscs, or Shell-fish. Here by far the greater number of species are aquatic, and breathe by gills, so that we may regard those which are swimmers as being primitively so. Although the adults of the Bivalve Molluscs are either fixed to some solid substance (Oysters), or are merely capable of leaping or turning (Cockles and Fan-shells), yet in their young state all these Molluscs are free swimmers, young oysters being provided with swimming organs composed of delicate hairs. It thus seems probable that these locomotive habits have been transmitted to the young bivalves from originally free-swimming ancestors.

The ordinary Sea Snails (Gastropods), in which the adult creeps on solid surfaces by means of its greatly expanded "foot," are also free swimmers when first hatched, the swimming being effected by means of vigorous flappings of a pair of fins attached near the head. A similar structure and habits have been retained in the adult by the Pteropods, those small translucent Molluscs, of pelagic habits, which are so abundant in some of the northern seas, and afford a considerable proportion of the food of certain species of whales. A well-known writer states that "Multitudes of these little things may now and then be seen on the surface of the water, fluttering with their wings and glittering in the sunshine, to be compared with nothing more aptly than a congregation of the more dressy of the Bombyx Moths."

Although not a true swimmer, the well-known Violet Snail (*Ianthina*) is able to float on the surface of the ocean, either by expanding its "foot," or by developing at certain seasons a peculiar membranous raft-like structure, the cells of which are filled with air, and beneath which the eggs are carried.

A totally different mode of progression through the water is adopted by that group of Molluscs technically known as Cephalopods, in which the head is surrounded by a circle of long prehensile arms, provided with adhesive suckers. This group comprises the existing Cuttle Fishes, Squids, Argonauts, and Nautili, as well as the extinct Ammonites (Fig. 2), and a host of other fossil forms. In

Fig. 2.—Shell of Ammonite.

the free swimming forms, locomotion is effected by the forcible expulsion of a jet of water from a funnel situated near the head, and directed forwards, the result of which is to propel the animal forcibly backwards. Minor aid in swimming is afforded either by expansions of the skin on the sides of the body, or by distinct fins near the tail; while many of these creatures aid their escape from foes by the sudden discharge of an inky fluid during their backward course.

Our notice of Swimming Invertebrates cannot be concluded without mention of those curious marine animals known as Sea-Squirts, and technically as Tunicates—a group usually placed in the neighbourhood of the Molluscs. Although in the adult state many of the Tunicates exist in the form of the bag-like squirts with which many of us are familiar, yet all are free-swimming creatures in the young condition. Moreover, certain of them, like the Salpæ, are pelagic throughout their existence; some of the latter forming chains composed of numerous individuals attached to one another. These Salpæ-chains vary in length, from a few inches to several feet, and swim on the ocean surface with a serpentine movement. The great interest attaching to these Tunicates is that the young exhibit certain structures closely simulating the primitive condition of the spinal column of Vertebrates, and thus suggesting that they are degraded types allied to the original stock from which the Vertebrates themselves are descended. This is very important as regards the derivation of Vertebrates from aquatic animals;—an origin which we should naturally expect, seeing that fishes breathe by means of gills, and are, therefore, presumed to have had aquatic ancestors.

(*To be continued.*)

ON THE SPACE-PENETRATING POWER OF LARGE TELESCOPES.

By A. C. Ranyard.

Unless there is some small star or dimly shining body with a large parallax which has not yet been detected, our nearest neighbour amongst the stars is the double star α *Centauri*. It is situated about thirty degrees from the southern pole of the heavens, and therefore is not visible in England. The two stars together shine with a light which is a little greater than that of a 1st magnitude star, for the larger of these twin suns is ranked by Prof. Gould as being exactly of the 1st magnitude of the photometric scale, and the smaller star is of the $3\frac{1}{2}$ magnitude.

According to this photometric scale of magnitudes, which is now universally used, a star of the 1st magnitude gives just 100 times as much light as a star of the 6th magnitude. Consequently, if the larger star of the pair, which is known as α^2 *Centauri*, were removed to ten times its present distance, it would appear as a star of the 6th magnitude; but this would only be the case if there were no loss of light in travelling from its more distant position. If there were any absorption of light in passing through such a vast distance of space, it might appear smaller and would probably not be visible to the naked eye, for few people see stars with their unaided eyes which are ranked as smaller than the 6th magnitude. According to the photometric scale, a star of any magnitude gives about two and a half times as much light as a star of the magnitude immediately below it. Thus a star of the 6th magnitude gives 2·512 times as much light as a star of the 7th magnitude, and a star of the 7th magnitude gives 2·512 times as much light as a star of the 8th magnitude. Consequently a star of the 6th magnitude gives 6·31 times as much light as a star of the 8th magnitude, and 15·85 times as much light as a star of the 9th magnitude, 39·81 times as much light as a star of the 10th magnitude, and 100 times as much light as a star of the 11th magnitude.

Let us suppose that α^2 *Centauri* was removed to 100 times its present distance, then, neglecting the absorption of light in space, it would shine as a star of the 11th magnitude of the photometric scale, and would only just be visible with a telescope of two and a half inches aperture. This calculation is based on the assumption of Prof. C. A. Young* that, for normal eyes, with a good telescope, the *minimum visible* for a one-inch aperture is a star of the 9th magnitude—an estimate which about corresponds to what might be expected from the diameter of the pupil of the eye.

I have measured the diameter of the pupils of several persons whom I believed to have keen sight, amongst others, the observing eyes of the Rev. T. W. Webb, Mr. Burnham, and the late Dr. H. Draper, and have found that about a quarter of an inch generally corresponds to the maximum dilation of the pupil in viewing faint objects. A telescope of one inch diameter would, consequently, collect about sixteen times as much light as would enter the pupil of the unassisted eye, and ought, with a suitable eye-piece, to show stars giving about $\frac{1}{16}$th the light of a 6th magnitude star just visible to the naked eye. As we have seen above, a 6th magnitude star gives 15·85 times as much light as a 9th magnitude star of the photometric scale. Consequently, neglecting the absorption of light by the lenses, and the reflection from their surfaces, a one-inch telescope ought, with a suitable eye-piece (which collects and sends into the pupil of the eye the whole of the light from the object-glass), to render stars of the 9th magnitude just visible.

The power used with a telescope makes some difference, as it increases the contrast between the brightness of the star and the background on which it is seen—the light of the background being dimmed by magnification, while the star in a good defining telescope is but slightly dimmed by moderate magnification. Thus Dawes found that he could see a star of the 6th magnitude with a telescope having an aperture of only 0·15 inches when a power of $16\frac{1}{2}$ was used. In the case of the one-inch telescope above referred to, the loss of light by absorption and reflection at the surfaces of the lenses seems to be about balanced by the increase of contrast with the background, due to the power employed.

Let us suppose that α^2 *Centauri* were removed to a thousand times its present distance, then, neglecting the absorption of light in travelling through space, it would appear as a star of the 16th magnitude, and would only just be visible with a telescope of 25·12 inches aperture, and if it were removed to 1585· times its present distance, it would shine as a star of the 17th magnitude of the photometric scale, and would only just be visible in a telescope

* See Prof. Young's *Text Book of General Astronomy*, sec. 822.

of 39·81 inches aperture. That is, it would not be visible in the great Lick 36-inch refractor.

These calculations are based on the assumption that there is no absorption of light in passing through great distances of space, and also on the assumption that there is no loss of light in passing through such thick lenses. The thickness of the object-glass of the "Washington" 26-inch refractor at its centre is nearly three inches; thus, the flint glass lens is there 0·96 inch thick, while the crown glass lens is 1·88 inch thick at its centre. Such a thickness more than halves the intensity of the emergent pencil; and the loss of light by absorption in passing through the glass near the centre of the Lick object-glass must be considerable. Exact measures of the absorption of light by such great lenses would be of much interest. We may, however, probably assume with some confidence, that if α^2 *Centauri* were removed to twelve hundred times its present distance it would not be visible in the Lick telescope, even though there were no absorption of light in space; and α^2 *Centauri* is probably larger and brighter than our Sun.*

Stars smaller than our Sun would be lost to sight at smaller distances. Consequently the Milky Way must either be nearer to us than a thousand times the distance of α *Centauri*, or the smallest stars visible in it with a telescope as large as the Washington 26-inch refractor must be larger than our Sun—a supposition at which the mind rebels when we remember the vast size which this would imply for the larger stars evidently involved in or associated with the Milky Way. For example, in the Pleiades group (which we showed reason in the May number for believing to be associated with the Milky Way) there are observable with the eye at the telescope a range of some thirteen magnitudes of the photometric scale, which, translated into ordinary language, means that the larger stars of the cluster give more than a hundred and fifty thousand times as much light as the smaller stars of the cluster.

In the photographs of the Pleiades cluster we have evidence of a range of at least fifteen magnitudes, which means that the larger stars give a million times as much light as the smaller stars, and in the photograph of the Coal-Sack region of the Milky Way, published in the June number, there is evidence of a still greater range of magnitudes. The star α *Crucis*, which is of the 1·3 magnitude, is evidently associated with a dense cluster of small stars, branches from which can be traced far across the Coal-Sack region, and extending to a considerable distance over the Milky Way or into the Milky Way to the north of α *Crucis*. We seem to have in this instance evidence of a range of at least seventeen magnitudes. And the proof of the connection between the large star and the small stars of the cluster is far stronger than as stated by me in the May number. α *Crucis* is a double star with components about 5 seconds apart and there are several small companions that have been observed in the telescope. In the glass photograph sent me by Mr. Russell the spurious disc of the large star is, when examined with a magnifier, seen to contain several small stars forming a cluster about the large one. Indeed, in the plate published in the May number some seven or eight of these small stars may be recognized with a magnifying-glass on the edge of the spurious disc of the large star.

Though the mind may at first be staggered by the conception of stars giving a million times as much light as our Sun, we are not in a position to deny the existence of such vast sun-like bodies. Indeed those who accept the nebular hypothesis as giving the most probable explanation of the origin, or rather of the birth of the planets of the Solar system, must be prepared to believe that there was a time when the Sun had a diameter as large, or nearly as large, as the diameter of the orbit of Neptune. If before these more than geologic ages of radiation into space the surface or photosphere of the solar mass did not shine as brightly as it shines now, it must, at least, have been a nebula with a very definite surface, which, as seen from a distance a hundred times as great as that of α *Centauri* would have presented a disc nearly half a second in diameter. No disc has at present been observed to any star; we may therefore feel some confidence that there is no such vast sun-like body within a distance from us equal to fifty times the distance of α *Centauri*.

In the forthcoming part of the *Old and New Astronomy*, I have shown reason to believe that there is evidence of absorption of light in space, and that we can, from the numbers of the stars of the various magnitudes, make a rough minimum estimate as to the amount of absorption of light in space, due either to a want of perfect elasticity in the light-transmitting ether, or to dark bodies cutting out or obliterating the light in its passage through space. This greatly reduces our idea of the magnitude of the region we can explore with the telescope and with the camera—α *Centauri* would probably be lost to the Lick telescope if it were removed to three hundred times its present distance—and it also greatly reduces our idea of the distance of the small stars of the Milky Way, and of the scale of the galactic system as well as of the nebular system and of the system of clusters, red stars, and bright line stars which are so evidently associated with it.

It is not so very long ago that it was generally taught that the nebulæ were galaxies of stars more or less similar to the Milky Way that surrounds us, but so inconceivably remote as to appear when observed with the largest telescopes like small spots in the heavens. This theory suited the popular taste, and died hard. It involved the assumption that man could explore with the instruments at his disposal a space so immense that the interstellar spaces which we can just measure or guess at, are dwarfed into points beside the distance from which light travels to us.

The theory should have been disposed of by the observations of Sir William Herschel, who noted that many nebulæ are evidently associated with stars, and observed that the smaller nebulæ were distributed over the heavens in a manner which shows an intimate connection between them and the brighter stars. He noted that the nebulæ in the northern heavens were clustered in the pole of the Milky Way, and descended like a canopy on all sides, leaving a dark space or channel separating the nebulous region from the rich stellar region of the Milky Way. Sir William Herschel also fully satisfied himself that "there were nebulosities which are not of a starry nature," and from his observations of diffused nebulæ he formed his well-known hypothesis of a diffused luminous fluid which, by its eventual aggregation, produced stars. But he did not proceed to the legitimate deduction from his observations as to the general distribution of nebulæ, viz.: that nebulæ which are arranged so symmetrically with respect to the stars must belong to the stellar system, and therefore cannot be assumed to lie at immense distances compared with the distance of the Milky Way stars.

* Assuming with Mr. Gore a period of 77 years for this binary, and a parallax of ·75 of a second, the sum of the masses of the components will be 2·14 times the mass of the Sun.

Sir John Herschel extended the observations of his father to the southern heavens, and showed that there was a similar clustering of the smaller nebulæ on the southern side of the Milky Way, and a similar intimate connection between the distribution of stars and the distribution of nebulæ in the southern hemisphere (see *Cape Observations*, p. 134); but it was not till 1858 that the obvious conclusion from these observations was drawn by Mr. Herbert Spencer in a remarkable paper on "The Nebular Hypothesis," published in the *Westminster Review*. He remarked, "If there were but one nebula, it would be a curious coincidence were this one nebula so placed in the distant regions of space as to agree in direction with a starless spot in our own sidereal system. If there were but two nebulæ, and both were so placed, the coincidence would be excessively strange; what then shall we say on finding that there are thousands of nebulæ so placed? Shall we believe that in thousands of cases these far-removed galaxies happen to agree in their visible positions with the thin places in our own galaxy? Such a belief is impossible."

Mr. Herbert Spencer's paper was not illustrated by charts, and the force of his reasoning was not generally perceived till some ten years afterwards, when Prof. Cleveland Abbé drew attention in the *Monthly Notices* of the Royal Astronomical Society for May, 1867, to the intimate connection between the distribution of nebulæ in space and stars; and Mr. Proctor, in 1869, constructed some charts on an equi-surface projection, which graphically put his readers in possession of the facts and carried conviction to all who read his remarks.

The theory that the nebulæ were distinct galaxies involved the assumption that light can reach us from regions many thousand times more remote than the stream of stars which compose our own galaxy; and it also involved the assumption that the matter of the universe is aggregated into clusters, separated by immense barren spaces, in which we must assume that there are very few luminous stars, and but few dark stars which would absorb light, as well as comparatively very little opaque matter distributed as meteors are distributed in the region of space we are familiar with.

We have evidence that the greater part of the lucid stars belong to the galactic system, but the large proper motion of some stars, taken in conjunction with their small parallax, affords evidence, as Prof. Simon Newcomb has pointed out, that they will in time pass away from our galaxy.* The regions outside our galaxy cannot, therefore, be absolutely barren, but however sparsely luminous stars are distributed through space, if there were no absorption of light in its passage through the ether, and no opaque bodies to blot out the light of distant stars, it would be impossible, as Olbers long ago pointed out, to draw a line in any direction which would not in an infinite universe pass through some luminous star, and the whole heavens ought to shine with the average brightness of such stars.

That the heavens are comparatively dark may, therefore, be taken as proof either that the light-transmitting ether is not perfectly elastic, or that there are numerous dark bodies in space that blot out the light which we should otherwise derive from the more distant parts of the universe.

* Prof Simon Newcomb has shown in his *Popular Astronomy* that making the most liberal assumptions as to the number and masses of the stars of our galactic system, the highest speed which a body could attain if it fell from an infinite distance through such a stellar system would be 25 miles a second, a velocity which is certainly smaller than that of many stars.

THE MAGIC SQUARE OF FOUR.

To the Editor of Knowledge.

Dear Sir,—It may interest some of your readers to know that the deficiency of 32 squares (short of Frenicle's total of 880), mentioned in my letter in the April number of Knowledge, has been supplied by Dr. J. Willis, of Bradford, who has seen Frenicle's collection and given it a careful examination. It appears that Type C (*vide* my article in March number) really has 304 varieties, and not merely 272. I may as well mention at the same time, in justice to Mr. Cram, that it was through an oversight that I obtained only 80 extra squares of this type from him. He meant to have given me seven instead of five, in which case I should have had 7×16 instead of 5×16 extra.

The following analysis of Frenicle's number may, therefore, be now considered as correct:—A, B, D, each 48; C, 304; E, F, each 96; G, I, J, L, each 56; and H, K, each 8.—Total 880.

Whilst writing, I may perhaps be allowed to make two other corrections in my article. The first is a misprint; page 47, first column, the first row of the square (1) should be 1 6 11 16, not 1 6 11 6. Lastly, the first sentence in the last paragraph in the same column is wrong. The four varieties mentioned in the third line are obtained by transposing 0 for 8, and 4 for 12, and *vice versa* (which doubles the number of squares), and then transposing the two centre columns (which again doubles the number), thus making four varieties.

In conclusion, it may be worth while to quote Dr. Willis's opinion, that "it is extremely improbable that other squares of four exist in addition to these 880, as Frenicle appears to have proceeded by finding by trial all those combinations which satisfy the conditions that the sum of the four corner numbers, as well as that of the four numbers in the middle of the square, must equal the normal 34."

T. S. Barrett.

[P.S.—Frenicle's articles, in which his 880 squares occur, may be seen in the British Museum. They are printed in a volume entitled "Divers Ouvrages des Mathematique et de Physique, par Messrs. de l'Academie Royal des Sciences; Paris, 1693." This book is catalogued under the name Frenicle de Bessy, and its library mark is 49 f. 1.]

Mr. P. F. Kendall, F.G.S., wishes us to announce that a Committee has been formed for collecting information with respect to masses of Rock or Boulders distributed over the North-West of England. Mr. Kendall, whose address is 16, Leegate Road, Heaton Moor, Stockport, is acting as Secretary of the Committee, and will be glad to communicate with anyone willing to collect information in their district for the Committee.

THE OBSERVATION OF RED STARS.

By Miss A. M. Clerke, *Authoress of "The System of the Stars," and "The History of Astronomy during the 19th Century," &c., &c.*

"WHY should not stars change in colour as in light?" Baron Von Zach asked tentatively close upon seventy years ago, and the remark gave point to his re-publication, in 1822, of "Lalande's List of Red Stars," the first compiled with the help of the telescope. Now, excellent reasons might be found why such objects should

not vary in tint. If, for instance, Mitchell had hit the truth with his conjecture in 1767, that Antares, Aldebaran, and their fellows glowed with the ruddy light of decaying incandescence, they could obviously be subject only to changes proceeding in the uniform direction of the still further deepening and darkening of their fires. But if such variations as Von Zach anticipated *do* actually occur, then the reasons prohibitive of them must necessarily be invalid. As a matter of fact, do they occur? A great deal of evidence, recently accumulated, tends to show that they do. If this be so, and the conditions producing redness in stars should prove to be fluctuating, it becomes evidently inadmissible to make colour, directly or indirectly, a test of relative standing. What comes and goes cannot be the badge of what is permanent.

Stellar hues depend mainly, perhaps exclusively, upon the composition and extent of stellar atmospheres. Unveiled stellar photospheres would probably all agree in the display of a bluish tinge; but on this point inference and conjecture are our only guides; experience keeps aloof. What is thoroughly ascertained, on the other hand, is that the light which we receive from the stars is a residuum; it is what gets through the sifting apparatus, by various makes and modes of which they are all, without exception, surrounded. The resulting colours differ, just because the sifting apparatus *is* of various makes and modes. The more powerfully it acts, moreover, the redder, as a general rule, are the transmitted rays, because the quick, short, blue and violet vibrations get predominantly entangled and stopped in gaseous envelopes of normal constitution. A corresponding effect is produced in our own atmosphere; hence, the sun at the zenith is nearly white, but shows at the horizon, where selective absorption exerts all its strength, a more or less reddened disc.

More or less. The effect is not always the same. Often barely tinged with orange, at certain times our luminary disappears vividly glowing in crimson or scarlet. In other words, the setting sun is a colour-variable. And why? Plainly because the state and composition of our atmosphere are not always the same. The proportion of water-vapour held in suspension is one inconstant element; another is the amount of floating dust-particles subsiding in still air, or ceaselessly borne onwards by untiring upper currents. And this may help to illustrate the cause of stellar fluctuations in hue. It is, unquestionably, to be found in changes of temperature, of chemical constitution, of electrical condition, or of all three together (for they are pretty sure to be mutually interdependent) taking place in the glowing vaporous envelopes determinant of star-colours.

Their fluctuations must then be evident in the spectrum, as well as to the eye. Spectroscopic change, indeed, is only a re-affirmation, under a different form, of colour-change; the prism analyzing what the eye perceives. Colour sums up, in one subjective impression, the whole series of facts separately stated in each star-spectrum. The subjective impression needs accordingly to be tested and interpreted by the statement of fact. Its differences from time to time, or from person to person, are indicative merely; they may sometimes be admitted as assertions, but they must be unusually well established before they can amount to demonstrations of objective change.

It has long been known that the ruddy tinge of periodical stars, like Mira, lightens and deepens with their gain and loss of brightness; and it has lately been ascertained that remarkable spectral appearances accompany and explain these transitions. In other cases, spectra have been observed to vary independently of any noticeable concomitant effect upon either light or hue. Some exceptional objects, again, show, it would seem, marked changes of colour apart from changes of brightness; and these alone are properly entitled "colour-variables." Such of them as are in systemic connection with neighbouring bodies display a wide prismatic diversity, and both in themselves, and by their instability, give rise to highly intricate considerations; while the phases of solitary colour-variables consist entirely in the paling, or even total disappearance of their customary red hue.

Ostensible instances of this kind are numerous; a few are fairly well-authenticated. Take the eighth magnitude star in Virgo (148 Schjellerup), numbered 352 in the "Espin-Birmingham Catalogue of Red Stars." It shows a finely developed banded spectrum of the third type, and shines by Dunér's estimate in his catalogue of such objects, with a deep red yellow light. Mr. Espin noted its "fine pale red" tint, May 12th, 1885, described by Lord Rosse in 1841 as "scarlet," by d'Arrest in 1866 as "dark red." These, however, are but trifling discrepancies compared with the alleged total absence of colour from the star on May 8th, 1874. Its whitness at that date is attested by one—unfortunately only one—observation of Birmingham's. Any recent notes of its colour which may happen to have been made, would be of special interest for purposes of comparison with the older records. Those relating to the star 90 Schjellerup (Espin-Birmingham 221) are still less mutually reconcilable. But here there is just a possibility—though a remote one—that two different stars, one white, the other orange, may be in question. No shadow of doubt, however, overshadows the identity of a star in Orion (63 Schjellerup) numbered 1888 in the "Copenhagen Catalogue for 1864," which appeared red in 1863, and is now no longer so. Schjellerup perceived in 1870 that the hue he had originally been struck with had vanished. A 7·5 magnitude star in Scutum Sobieski (Schjellerup 214, Espin-Birmingham 544) may with some confidence be pronounced variable in colour. Of its redness, first perceived by Schjellerup, Birmingham could see no trace in repeated observations made in the years 1872-4; twice, indeed, he qualified the object as actually *blue*. But it had reverted, on September 29th, 1889, according to Mr. Espin, to a "pale orange red"; and since its spectrum is a banded one of the third type, it may claim to rank normally—its occasionally blanched aspect notwithstanding—as a red star.

It must here suffice to add one further example from the southern skies. It is that of *r* Velorum. Dr. Gould, at Cordoba, found the colour of this bright star (5·3 magnitude) so pronounced as in part to baffle estimates of its brightness. But judging from two observations of my own at the Cape, it had completely lost this quality in the autumn of 1888, and my eyes are rather extra-sensitive to the warmer tints of the spectrum. An examination of the star by Mr. Tebbutt in New South Wales, March 3rd, 1891, showed it "to be very slightly tinged with red," though, with a larger instrument (an eight-inch equatorial), three days later, the tinge seemed more decided—"very decided," indeed, "compared with the other smaller, but white stars in the same field of view."* The recovery of colour, however, is still evidently very imperfect. Mr. Tebbutt, one is glad to learn, does not intend to lose sight of this interesting object.

Up to the present, suspected colour-variables have been unaccountably neglected, notwithstanding the great importance both of verifying and of investigating their changes. For they supply what Bacon called "migratory instances," which, in the course of their journeyings from

* Journal of the British Astronomical Association, vol. I., p. 423.

one class to another, may be expected to prove instructive as to the essential characters of each. The very fact that such migratory instances are to be met with is in itself significant. It assures us, at any rate, that red and white stars are not the products of widely separated epochs of cosmical history. But besides this piece of negative information, much positive intelligence should be derivable from them. The co-ordination of spectral and colour-change has never yet been satisfactorily accomplished. The two kinds of variation are so far united that although the former might conceivably take place without the latter, the latter inevitably involves the former. Thus a star spectrum might, although it is unlikely that it would, vary fundamentally in character without any attendant variation in tint. This would be the case, for example, if emergent bands or lines were so situated as to be complementary one to the other. And in point of fact, relatively trifling modifications of colour appear to have been concomitant with the striking spectral changes detected by Mr. Espin in R Coronæ and R Scuti. But colour-variation *must* be explicable, so to speak, by spectral variation. Enquiries on this head are superfluous, their upshot being self-evident. What needs to be investigated is the form and manner of a correspondence which unquestionably exists. In this direction next to nothing has been done; to the questions that suggest themselves no answers are forthcoming; yet by their means, if at all, the enigma of star-colours ought to prove soluble. A thorough examination of a single colour-variable in its slowly alternating red and pale phases could hardly fail to disclose the essential condition of the peculiarity of its light. What supervenes, one desires to know, in the atmosphere of that star, now to blanch, and again to flush its rays? Are they subtracted from by additional absorption, or reinforced by special but transient emissions? Is continuous absorption included among the elements of change? That is to say, does the dusky veil thrown over the upper part of the spectrum appreciably lift or lighten with the paling of colour? The providing of definite replies to these definite queries would in itself make a solid beginning of knowledge as regards the cause of redness in stars. But they can only be provided by the persevering exertions of some one competent observer. Such disjointed notes of colour as have been hitherto visually recorded are of little use except in the way of suggestion. They have furnished the means of constructing a working list of objects more or less vehemently suspected of change, and thus served their main purpose of prescribing the aim, and limiting the scope, of a fresh series of more concentrated operations. Half-a-dozen red stars assiduously watched would probably be found more genuinely communicative than hundreds passed in review, and then abandoned until perhaps recovered after a decade or two by some other collector of celestial curiosities, whose perplexities at certain incongruous results of his search would remain as unprofitable as those of his predecessor. But the half-dozen stars chosen for detailed scrutiny should be tested spectroscopically and spectrographically, no less than visually. The photographic delineation of the spectra of small red stars would no doubt demand large instruments; yet without it the enquiry would be lamentably incomplete. Indeed, the tell-tale modifications looked for would be more likely to present themselves in the higher than in the lower reaches of the spectrum. From its exceptional brightness among colour-variables, *r* Velorum might be singled out as a particularly tempting subject for investigations of the kind described, were not astro-physical observers and apparatus equally scarce in the southern hemisphere.

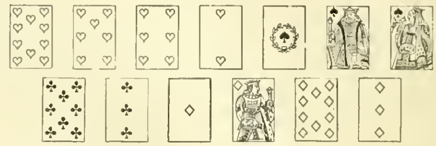
Whist Column.

By W. Montagu Gattie, B.A.Oxon.

Refusing to Overtrump.

Cases frequently arise in which it is not advisable to overtrump. The following hand furnishes a simple illustration.

Hand No. 22.

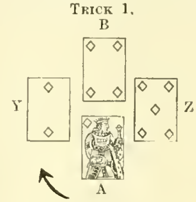


A's Hand.

Score—Love all.
Z turns up the three of hearts.

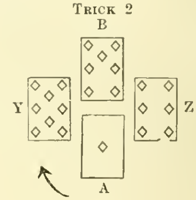
Note.—A and B are partners against Y and Z. A has the first lead; Z is the dealer. The card of the leader to each trick is indicated by an arrow.

Trick 1.



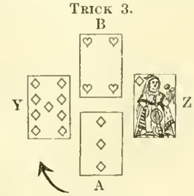
Tricks—AB, 1; YZ, 0.

Trick 2.



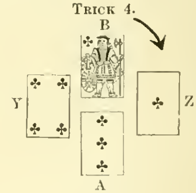
Tricks—AB, 2; YZ, 0.

Trick 3.



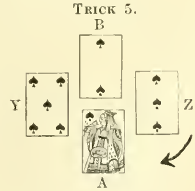
Tricks—AB, 3; YZ, 0.

Trick 4.



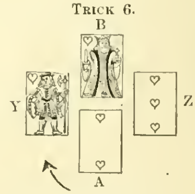
Tricks—AB, 3; YZ, 1.

Trick 5.



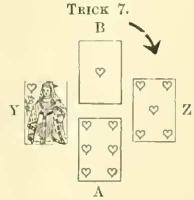
Tricks—AB, 4; YZ, 1.

Trick 6.



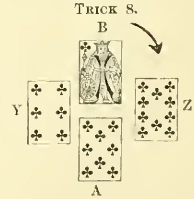
Tricks—AB, 5; YZ, 1.

Trick 7.



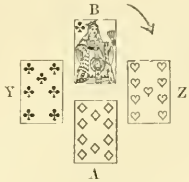
Tricks—AB, 6; YZ, 1.

Trick 8.



Tricks—AB, 7; YZ, 1.

Trick 9.



Tricks—AB, 7; YZ, 2.

Note.—A discards his losing diamond instead of overtrumping, and so secures the game. He might infer from Z's nine of hearts that B holds the eight; but the nine may be a false card (as is indeed the fact), and in that case Z will save the game if he has the best spade after three rounds, unless A allows him to win this trick. For, after overtrumping, A cannot prevent YZ from making either the knave of spades or the knave of diamonds as well as the eight of trumps.

Tricks 10 *to* 13.—Whatever Z leads, A makes the remaining tricks, and

AB Score Five by Cards.

A's Hand.	B's Hand.
H.—10, 7, 6, 2.	H.—Ace, Kg, 4.
S.—Ace, Kg, Qn.	S.—10, 6, 2.
D.—Ace, Kg, 10, 3.	D.—7, 4.
C.—8, 3.	C.—Kg, Qn, Kn, 5, 2.
Y's Hand.	**Z's Hand.**
H.—Qn, Kn.	H.—9, 8, 5, 3.
S.—8, 7, 5.	S.—Kn, 9, 4, 3.
D.—Kn, 9, 8, 2.	D.—Qn, 6, 5.
C.—9, 7, 6, 4.	C.—Ace, 10.

This is purposely given as a very simple example of the disadvantage of overtrumping in like circumstances, and A's proper play may seem to many readers too obvious to need demonstration, since it is clear that, after discarding his diamond, he must win every other trick. Yet it is surprising how often such opportunities are missed in actual play. Next month we hope to give a somewhat more difficult illustration of the same principle.

Chess Column.

By C. D. Locock, B.A.Oxon.

To Correspondents.—Communications for this column should be addressed "*Cintra, Hawkhurst, Kent,*" and posted *before* the 10th of each month.

Solution of Problem No. 1 (*by W. E. Bolland*):—1. K to K3, and mates next move.

Correct Solutions from:—Alpha, T. E. Kerrigan, T. Hurley, R. T. M., Giu. Pianissimo, K., J. Landan, F. A., A. G. Hansard, T. A. Earl, T. K. Bentley, R. W. Houghton, F. W. Sharp, White Knight, A. J. Luisham, G. F., J. Humble, A. N. Brayshaw, E. B., Betula, C. S., A. C. L. Wilkinson, M. B. (Jesmond), R. A. Layton, C. T. Blanshard, J. Johnston, J. G. Ellis, A. Rutherford, T. H. Billington, and T.—(30 correct; 2 incorrect.)

H. S. B.—Not quite right. If 1. K to B2, Q × R, and there is no mate.

F. de F. (Perugia).—After 1. K to B4, Q × R; 2. Kt × Qch is not mate.

G. F.—Thanks for problem, which we insert; it is quite good enough. Owing to a misprint in your key-move we thought at first that there must be two solutions.

J. G. Ellis.—Quite right, of course. Seeing the win of the Queen we looked for nothing else.

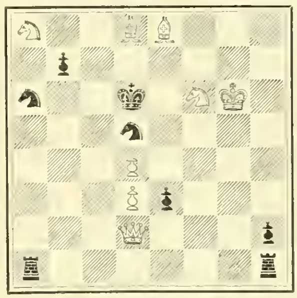
T.—Notice in July number reads, "*posted before* the 10th," which is, of course, identical with "on or before the 9th." Problem enclosed is hardly legible; and if legible, unsound.

H. C. H. and J. Taylor.—Too late for acknowledgment with the rest; will credit next month if no objections are raised.

PROBLEM (No. 2).

By G. F.

White.



Black.

White to play, and mate in three moves.

The attention of solvers is called to the rule that in the case of *three-move* problems all *White's second moves* should be sent. Competitors' scores will be published next month.

Game played, July 1st, in the Divan Tournament:—

Ruy Lopez.

White. (N. Jasnagrodsky.)	Black. (J. Mortimer.)
1. P to K4	1. P to K4
2. K to KtB3	2. Q to KtB3
3. B to Kt5	3. Kt to B3
4. Castles	4. Kt × P
5. P to Q4	5. B to K2
6. R to Ksq (*a*)	6. Kt to Q3
7. B × Kt (*b*)	7. KtP × B (*c*)
8. Kt × P	8. Castles
9. QKt to B3	9. P to B3
10. Kt to Q3	10. Kt to B2
11. B to B4	11. P to Q4 (*d*)
12. Kt to R4 !	12. B to Q3
13. QKt to B5	13. R to Ktsq
14. P to QKt3	14. R to Ksq
15. Q to B3	15. B to Q2 (*e*)
16. R × Rch	16. Q × R
17. R to Ksq	17. Q to QBsq
18. P to KR3	18. B to B4 (*f*)
19. Q to Kt3 (*g*)	19. P to Kt4
20. B × B (*h*)	20. P × B
21. Kt to R4	21. Q to Bsq ! (*i*)
22. Q to K3	22. R to Kt2
23. P to KKt4 (*j*)	23. B to Kt3
24. P to KB4	24. B × Kt
25. P × B	25. P × P
26. Q × P	26. Kt to Kt4
27. K to R2 ? (*k*)	27. R to K2
28. R to KBsq ?	28. Q to R3
29. Q to Kt3 (*l*)	29. R to K7ch
30. R to B2	30. R × Rch
31. Q × R	31. Q × Pch
Resigns.	

Notes.

(*a*) 6. Q to K2 is now more usually played, but against correct play it yields no advantage.

(*b*) 7. P × P is perhaps better. If then 7. . . Kt × B, 8. P to QR4, recovering the piece.

(*c*) 7. . . QP × B leads to an even game. Black probably wished to avoid the exchange of Queens, but gets thereby a rather cramped game. White's next move is better than P × P, for Black could then, after Castling, free his game by P to KB3.

(*d*) This leaves a weak point at QB4 to be occupied by the hostile Knights. He might try instead B to Q3 at once (White threatens B × P).

(*e*) In order to make room for the Queen at Bsq. Kt to Rsq also seems feasible, leaving a diagonal for the Queen to escape by, in case White exchanges Rooks, and ultimately developing by Kt to Kt3.

(*f*) Just in time to prevent his game being blocked by P to KKt4.

(*g*) White so far has played with excellent judgment, but has nothing more to do at present. His only chance of attack lies in working his Queen on to the QR file. The move actually made is cleverly taken advantage of by Mr. Mortimer to drive the QKt out of play; but *vide* note (*h*).

(*h*) If 20. P to KR4, P to KR3 (best); 21. P × P, RP × P; 22. R to K3! K to Bsq; 23. B × B, P × B; 24. R to B3! B to K5 (If . . . P × Kt; 25. R × B); 25. R × P, P × Kt; 26. Kt × P, threatening to win by Q × R, Kt to Q7ch, and R × Ktch, and threatening also R × P or Q × P or Q to Q6ch according to circumstances. In any case White must get at least three Pawns for the piece sacrificed, and would probably win in actual play.

(*i*) With a view to R to Ksq, which White proceeds to stop. The move also frees his Knight.

(*j*) By this and his next move (which is of the nature of a blunder) White unnecessarily compromises his position. He should bring the QKt into play. Mr. Mortimer now takes up the attack in vigorous style till the end.

(*k*) K to Kt2 seems much better. Black now, noticing the position of the White Knight, is content to offer the exchange of Rooks. White, however, could still draw by accepting it. His next move is speedily fatal.

(*l*) 29. Kt to B3 would prevent the immediate catastrophe, but Black would win after 29. . . Q × Pch; 30. K to Ktsq, R to K6, &c. Again, if 29. . . . Q × BP, R to K7ch; 30. K to Kt3, R to K6ch! and wins easily.

KNIGHTS AND BISHOPS.

(*Continued from p.* 140.)

1. The first point to be considered, then, is extent of range. In this the superiority of the Bishop seems at first sight overwhelming. A Bishop commands a maximum of thirteen squares, and a minimum of seven; a Knight's maximum is eight, and its minimum only two. This superiority, however, is subject to important limitations. It should be noticed, for instance, that the Bishop commands its maximum number of squares, only when placed on one of the *four* centre squares; while a Knight commands its maximum when placed on any one of the *sixteen* centre squares, and this too regardless of obstacles. Moreover, in the earlier stages of the game a Bishop can very rarely be posted with advantage in the centre of the board; and unless this is so, its maximum is at once reduced to eleven squares.

2. A Knight can be brought to command any square on the board; a Bishop being, of course, limited to half the total number. The Knight's advantage here is especially prominent in a blocked position, or when Pawns have to be attacked in the end-game.

3. Nothing can prevent a Knight from commanding any square within its range. A Bishop, on the other hand, except in the end-game, is hampered even more by his own Pawns and pieces than by those of the other side; so much so, that a Bishop may be sometimes reduced to a state of total inactivity. But there is no imprisoning a Knight possessed of ordinary prudence.

Now comes a most important consideration. It is well known that a minor piece should generally be supported by a Pawn; and in the case of a Bishop, the very Pawn which supports it shuts it out from retiring in that direction, and very often from communication with the other wing, which should always, when possible, be kept open. For this reason the best position on the board for the King's Bishop is QKt3. A loophole for escape may be opened by P to QB3, and the Bishop, being defended by a *Rook's* Pawn, is not shut out from commanding any square within its range.

(*To be continued.*)

The British Chess Magazine for July contains a portrait of Buckle, the historian, with a sketch of his chess career illustrated by some of his games. Perhaps the most attractive feature of the number is a very readable review of Mr. Gossip's latest. A Problem Tourney with some novel features is announced.

A Tournament has been in progress some weeks at Simpson's Divan. The first prize lies between Messrs. Loman and Van Vliet; Messrs. Bird and Mortimer should take the third and fourth prizes. The other competitors are Messrs. Lee, Muller, Tinsley, Gossip, Fenton, and Jasnagrodsky.

A match of seven games up has been arranged between Messrs. Blackburne and Gunsberg. The *locale* is not yet decided on.

Contents of No. 69.

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CONTENTS.

NOTICE.

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GNATS, MIDGES AND MOSQUITOS.—III.

By E. A. Butler.

It is difficult for a stay-at-home Englishman, used only to the minor inconveniences caused by insects in this highly denaturalized country, to conceive the horror with which Gnats and Mosquitos are viewed in those more primitive regions in which they still exist in incredible multitudes, and to realise the terrible sufferings they are answerable for; he is inclined to treat the whole matter almost as a joke, and to laugh at the violence of the execrations which have been heaped on the heads of such insignificant offenders. But there can be no question that the plague has been and is still, in many parts of the world, a most real and serious one, and experience shows that the descriptions travellers have given of the numbers of the insects, and the pain and disfigurement caused by their attacks, highly coloured though they often seem, may yet be accepted as having a solid foundation in fact. The exact effect of a Gnat or Mosquito bite, however, upon the human body, varies with the species of insect which produces the wound, with the sensitiveness and temperament of the individual attacked, and with surrounding circumstances. On the borders of the great rivers of the Brazilian forest, where Mosquitos are probably as troublesome as anywhere in the world, the effect is quite different upon Europeans and natives. According to Humboldt, who paid great attention to the subject when he was in the region of the Upper Orinoco, blisters and swelling are not produced upon the skin of the natives, *i.e.*, the copper-coloured Indians, though such results follow in the case of the white man, new settlers being much more severely dealt with than old residents. Speaking of a white man who had had "his twenty years of Mosquitos," he says, "Every sting leaving a small darkish-brown point, his legs were so speckled that it was difficult to recognise the whiteness of his skin through the spots of coagulated blood." That, notwithstanding their immunity from the above secondary effects, the natives still suffer acutely, is manifest from the numerous and energetic devices they adopt to free themselves from the plague, as well as from the extent to which the Mosquitos form a staple subject of conversation. Elevated platforms have been resorted to as retiring places, since the flies are most numerous near the ground, the greater number not rising above 15 or 20 feet; a calico tent suspended from the branches of trees when in the forest, is another device, while indoors there are the well-known nets and curtains. Humboldt speaks of his boatmen as vigorously slapping one another's bare backs to drive away the tormenting insects, and as getting so used to the action that they sometimes slapped themselves in their sleep; some rubbed the wounds on their comrades' backs with rough bark (!) or again, the women patiently set themselves to pick out from the pustules the drops of coagulated blood. "How are you with regard to the Mosquitos?" was a common form of salutation, while to the native mind, the absence of Mosquitos formed the highest conception of the bliss of heaven. "How comfortable must people be in the moon," said an Indian to his European teacher, "she looks so beautiful and so clear, that she must be free from Mosquitos!"

Dr. A. R. Wallace, visiting the same region, says: "Immediately after sunset they poured upon us in swarms, so that we found them unbearable, and were obliged to rush into our sleeping-rooms, which we had kept carefully closed. Here we had some respite for a time, but they soon found their way in at the cracks and keyholes, and made us very restless and uncomfortable all the rest of the night." And so far from getting used to them: "After a few days' residence we found them more tormenting than ever, rendering it quite impossible for us to sit down to read or write after sunset." The people used dried cow-dung burnt at their doors to keep away the insects, and this seemed the most effectual remedy, so that by adopting it, and walking about at the same time, the explorer managed to "pass an hour pretty comfortably." Mr. H. W. Bates, speaking of Fonte Boa, also in the same region, says that, "in addition to its other amenities, it has the reputation throughout the country of being the headquarters of Mosquitos, and it fully deserves the title. They are more annoying in the hours by day

than by night, for they swarm in the dark and damp rooms, keeping in the daytime near the floor, and settling by half-dozens together on the legs. At night the calico tent is a sufficient protection, but this is obliged to be folded every morning, and in letting it down before sunset great care is required to prevent even *one* or *two* of the tormentors from stealing in beneath, their insatiable thirst for blood, and pungent sting, making *these* enough to spoil all comfort." From these extracts we see that the experience of the traveller in South America is by no means uniform, and this partly results from there being several distinct species of flies concerned in these attacks, some inhabiting one stream and some another, according to the character of the water, and having also their time of flight at different hours of the day and night. These peculiarities were particularly noticed by Humboldt.

Mungo Park considered that crocodiles were but of little account to the traveller in Africa, "when compared with the amazing swarms of Mosquitos, which rise from the swamps and creeks in such numbers as to harass even the most torpid of the natives." With his clothes almost worn to rags, he was ill prepared to resist their attacks, and frequently, therefore, passed the night walking backwards and forwards, fanning himself with his hat, perpetual motion being necessary to keep them at bay. Linné testified to their extraordinary abundance in Lapland, where smoke and grease were in his time, as they probably are still, the best preventives known. And in recent years, Nordenskiöld and others have recorded meeting with enormous swarms in high Arctic latitudes, in which regions, indeed, it is not only *Culices* that exist in myriads, but other *Diptera* as well. For instance, Dr. F. A. Walker, speaking of a visit to Iceland, mentions not only that bluebottles were to be found in great numbers on rotting fish everywhere, but especially that the little black flies that frequent seaweed on the sand flew in multitudes on board the steamer, blackening the windows of the deck saloon. Dr. Clarke, travelling in South Russia, tells a pitiful tale of the persecutions to which he was subjected in passing through a morass which teemed with Mosquitos to such an extent that a lamp which was lit in a closed carriage was soon extinguished by the swarms that flew into it.

As may be imagined from their habits and life-history, Mosquitos are not equally distributed in the countries in which they occur; in low-lying, marshy districts they are most abundant, but as one recedes from the water, or reaches greater elevations, they become less numerous. They attack not only human beings, but also cattle, and hence the proximity of the latter in places much infested may sometimes give relief to men; on the other hand, they have often been noticed accompanying cattle on their return from marshy pastures, clustering round them and thus becoming ultimately introduced into houses. It has been said that they object to the strong smell of the alligator, but if this be so, they can overcome their dislike when there is a chance of a draught of human blood, for Humboldt relates that while dissecting a large alligator, 11 feet long, the odour of which infected all the surrounding atmosphere, he and his assistants were fearfully stung. From the method of life of the Mosquito, especially in its early stages, it is clear that it would be next to impossible to transport them accidentally, except as perfect insects, from one country to another across large tracts of ocean, and the reports that are sometimes spread of Mosquitos appearing in hotels in this country frequented by Americans need to be received with great caution. Probably, in most instances, investigation would show that they were simply English Gnats rather more virulent than usual, which had been propagated in some neighbouring cistern or pond.

Opinions have differed as to the cause of the swelling and pain resulting from a Gnat or Mosquito bite. Some have maintained, in accordance with what has always been the popular belief, that effects of such magnitude could not be produced without the introduction of a poisonous fluid, though they have failed to show that any apparatus exists which would be capable of completely fulfilling such a function. Though this poisonous fluid is itself conjectural, a purpose has been assigned to it, viz., that of rendering the blood more liquid, so that it may the more easily be sucked up. And that some such function would have to be assumed is tolerably certain, since the poison could hardly be regarded merely as an implement of offence, and consequently an advantage to its possessor. It seems scarcely open to question that, apart from some such function for the poison as above, the insects could far more easily obtain the blood they covet, and far less precautions would be taken against them, if they did not produce any painful results and thus rouse the hostility of their victims, and that therefore, from that point of view, a poison could not be an advantage. If, therefore, a poison exists, its function must undoubtedly be to facilitate the drawing of the blood, and not to serve as a weapon.

Influenced by the anatomical difficulties above mentioned, other observers have maintained that no poisonous fluid is injected, but that the laceration of tissues produced by the six minute, acutely pointed, and in some cases barbed organs which constitute the borer, is sufficient to account for the inflammation and itching. This hypothesis, again, is not without objection. It would appear that the insect sometimes experiences difficulty in getting at the blood it desires, for deep perforations of the skin may be made without drawing blood, and then no swelling occurs, and little pain is felt; this certainly appears a formidable difficulty in the way of the latter explanation. Mr. G. Dimmock, one of the most recent experimenters with *Culices*, forcibly says: "I am convinced that there is use made of a poisonous saliva, for when biting, if the Mosquito fails to draw blood, which it often does on parts of the back of my hand, it may have inserted its proboscis nearly full length in from one to six directions in the same place, and withdrawn its proboscis; indeed, it may have inserted its proboscis, as often occurs, in extremely sensitive parts, yet in such cases, if no blood be drawn, no more effect is produced upon my skin than is produced by the prick of a sharp needle: a red point appears, only to disappear in a few hours. Certainly there has been as much tearing of tissues in such a case as above mentioned as there is when the Gnat settles on a place richer in blood, and with a single probing draws its fill." He remarks also that "the poisonous effect on me, as proved by numerous experiments, is in direct proportion to the length of time which the Gnat has occupied in actually drawing blood," and argues, perhaps somewhat inconsequently, that this indicates the constant outpouring of some sort of poisonous fluid during the blood-sucking process. But notwithstanding this, he was unable to detect any channel for the conveyance of poison into the wound. And, moreover, it is difficult to conceive of a double flow of liquid-poison downwards and blood upwards—as taking place simultaneously within the narrow compass of the proboscis of a Gnat or Mosquito. Or, again, if the movements were not simultaneous, but a downflow of poison were followed by an updraught of blood, it would seem that the greater part of the poison would be sucked out of the wound almost as soon as it was instilled, and that, therefore, it could hardly exercise much influence upon surrounding tissues. Hum-

boldt, who was a firm believer in the poisonous nature of the bite, considered this sucking out of the poison to be the explanation of the painlessness of some wounds. His experience was almost the reverse of that of Mr. Dimmock, as detailed above. He affirmed that if the insect were allowed to suck to satiety no swelling took place, and no pain was left behind, and considered that when pain was produced it resulted from the hasty interruption of the process of sucking, since then the last infused poison would not be able to be withdrawn. He experimented with one of the most virulent species, allowing it gently to settle on the back of his hand, and reports of it: "I observed that the pain, though violent in the beginning, diminishes in proportion as the insect continues to suck, and ceases altogether when it voluntarily flies away." The following experiment, however, seems to throw some doubt on the poison theory altogether. He says: "I wounded my skin with a pin, and rubbed the pricks with bruised Mosquitos, and no swelling ensued." On the whole, therefore, it must be admitted that great difficulties beset both of the two hypotheses that have been commonly advocated in explanation of the swelling and pain consequent on the bite. Of course similar remarks would apply in the case of both bugs and fleas.

There seem to be chiefly two species of true Gnats that infest houses in this country, which are named *Culex annulatus* and *ciliaris*. The former has pretty spotted wings, but must not be confounded with another spotted-winged Gnat-like fly (Fig. 4) which is frequently found in windows, and is generally called the "window Gnat" (*Rhyphus fenestralis*). The specific name *fenestralis* (from Latin *fenestra*, a window) was given to it in consequence of its usual habit of flitting about windows. It belongs, however, to a different family, and its habits and life-history are totally unlike those of the true *Culices*. Its larva is terrestrial, not aquatic, and lives in dung. *Culex ciliaris*, specially known as the "House Gnat," is a reddish-brown insect, with greyish wings.

Fig. 4.—Window Gnat (*Rhyphus fenestralis*).

The *Culices*, or true Gnats and Mosquitos, are not the only "thread-horned" flies that trouble mankind by sucking blood, though they are usually the chief; it is difficult, however, to give definite popular names for the other species. The word "Midge" is perhaps most commonly used as a general term for them, though it is also employed for insects of similar structure but of less annoying habits. To the genera *Simulium* and *Ceratopogon* belong some of the most annoying of these persecuting Midges, and some of the former become occasionally almost as bad a plague as the Mosquitos proper. The *Simulia* are also known as "sand flies," and in America, where they have occasioned great annoyance and trouble amongst the cattle, they are called "Turkey Gnats" and "Buffalo Gnats." They are small, dark-coloured insects, of a less fragile nature than the *Culices*, but still "thread-horned," and not therefore to be confounded with any of the "short-horns," such as the great, stout-bodied "breeze-flies," which are also terribly bad stingers. The flies have the peculiar habit of emerging from the chrysalis beneath the surface of the water. The *Ceratopogon*, which is sometimes troublesome in this country, is a minute greyish-brown insect; it is sometimes abundant in marshes and fens, where the females are very annoying.

But besides these, many other insects are called Midges, though they are not troublesome. There are, for example, first, the *Chironomi* or Plumed Gnats, the larvæ of one species of which are the grotesquely wriggling red, worm-like creatures, found in ponds and water-butts, and called "blood-worms." These are more uniformly cylindrical than the larvæ of the *Culices*, and besides wriggling about in the water, they construct amongst the mud at the bottom, tubes composed of particles of decayed leaves, fastened together with silken threads. The pupa, which is similar in shape to that of the *Culices*, and has an enormous fore-part, may be distinguished by the pair of exquisite white plume-like tufts that project from the sides of that part of the body. Each consists of five hairs, which are delicately fringed, so that the whole makes a large rosette. The pupa usually lies at the bottom helplessly, though it can swim, if obliged; a few hours before becoming a perfect insect it mounts to the surface to prepare for the change. The perfect insects are called "Plumed Gnats," because of their beautiful antennæ, which are even more deeply feathered than those of the *Culices*. They have no long beak, and are not adorned with scales like the true Gnats. These *Chironomi* form in the air dancing swarms which usually consist chiefly of males. Then there are the "Winter Midges" (*Trichocera*) which form little hovering swarms on bright days during winter and spring. These again are quite different from the Gnats, and belong to the daddy-longlegs group. The last "Midges" to which we shall refer are the family called *Psychodidæ*, most exquisite, though minute creatures (Fig. 5), some of which are commonly found in houses, on the walls, or running in little zigzags up and down the windows. They too are "thread-horns," but can be easily distinguished from the others by the peculiar shape and adornment of the wings. These are lancet-shaped, and are thickly covered with hairs, often so distributed as to form a pretty pattern, and this, coupled with the fact that they rest with wings not crossed over their backs as Gnats do, but spread out and sloping backwards at their sides, causes them to look like tiny moths. They are harmless little creatures, and their larvæ live in dung.

Fig. 5. Midge (*Psychoda*).

THE MINERALOGY OF METEORITES.

By Vaughan Cornish, B.Sc., F.C.S.

At various times and places, solid bodies of either a metallic or a stony character have been observed to fall from the sky, the occurrence, from circumstances of time and place, having evidently no connection with volcanic eruptions.

These bodies, termed Meteorites, possess peculiarities of mineral composition and structure which alone would serve to place them in a class apart from the ordinary rocks of the earth's surface. There are, however, differences of character among Meteorites themselves; which are for convenience classed as—

Siderites, Siderolites, Aerolites,

according as they are composed principally of metallic constituents (iron alloyed with nickel), of metallic and

stony constituents together, or, as in the case of aerolites, of stony minerals with no uncombined metals. The first class, Siderites, contain from 80 to 95 per cent. of nickeliferous iron. The most important characteristic of the first class is this constant association of nickel with the iron, and the peculiar crystalline structure known as Widmanstätten's figures, which are revealed when a specimen is cut, polished, and then submitted to the action of dilute nitric acid. A prominent peculiarity of the stony Meteorites is their *chondritic* structure, that is, they are composed of round grains imbedded in a ground mass of similar composition.

All Meteorites have a varnish or glaze on the surface, produced by their rapid passage through the air. This glaze shows that the surface has been subjected to a heat so intense as to fuse the material. The glaze is always very thin, pointing to the fact that the heating has been of very short duration, and has not had time to affect the inner portions.

Such are the chief features of the bodies which have been *seen* to fall from the sky. Now and again, in different parts of the globe, specimens are found on the surface which show the same well-known characters. These fragments are often found at a distance from any rocks having the least resemblance to them in mineralogical character, and where there is no evidence of transport by ice or water as in the case of boulders. Such specimens are placed in museums under the class "Meteorites," and in many instances the evidence is sufficiently cogent to leave no practical doubt of their origin being identical with that of the Meteorites the fall of which has been actually observed.

A very slight examination of the circumstances attending the fall of Meteorites, as, *e.g.*, their high velocity, is sufficient to show that they are not ordinary falling bodies, but that they have come from regions outside the Earth's atmosphere. Whether their ultimate origin is terrestrial, or from some other member of the solar system, or from regions beyond that system, it is not so easy to decide. The view which finds most general acceptance is that the Meteorites, like certain systems of shooting stars, move in orbits similar in form and range to those of the comets. Their supposed ex-terrestrial origin gives a certain fascination to the study of Meteorites. Viewed in the light of visitors from other worlds than ours, the comparison of their materials with the materials of our own earth becomes a matter of the highest interest. Hitherto, some four-and-twenty of the already-known chemical elements have been recognised in Meteorites, and no new element has been found in them. The principal elementary constituents are—

Iron,	Phosphorus,
Nickel,	Sulphur,
Magnesium,	Carbon,
Calcium,	Oxygen,
Aluminium,	Silicon.

The following occur in smaller quantities:—

Cobalt,	Titanium,
Manganese,	Lithium,
Chromium,	Sodium,
Copper,	Potassium,
Tin,	Hydrogen,
Antimony,	Nitrogen,
Arsenic,	Chlorine.

Of these nitrogen and hydrogen occur in the uncombined state as occluded gas. Carbon occurs uncombined, as graphite, as well as combined with oxygen. The following is a list of the mineral species which have been identified in Meteorites with the chemical formulæ as given by P. Groth (*Übersight der Mineralien*). The names in italics indicate species which have not been recognised among naturally-occurring terrestrial minerals. Of these Schreibersite, Lawrencite, Rhabdite and Troilite have been reproduced in the laboratory.

Anorthite, $Si_2\ Al\ O_8\ Al\ Ca$.

Augite and Diopside $(Si\ O_3)_2\ Mg\ Ca$; or, $(Si\ O_3)_2\ (Mg,\ Fe)\ Ca$.

Breunnerite, $C\ O_3\ (Mg,\ Fe)$.

Chromite $[(Cr,\ Fe)\ O_2]\ (Fe,\ Cr)$.

Daubréelite $(Cr\ S_2)_2\ Fe$ (crystalline form not determined).

Enstatite and Bronzite $(Mg,\ Fe)\ Si\ O_3$.

Hornblende $\left.\begin{matrix}(Si\ O_3)_2\ (Mg,\ Fe)_3\ Ca\ (Si\ O_3)_2 \\ (Si\ O_3)_2\ (Mg,\ Fe)_2\ Al_2\ (Al\ O_3)_2.\end{matrix}\right\}$

Labradorite, $\left.\begin{matrix}Si_2\ Si\ O_8\ Al\ Na. \\ Si_2\ Al\ O_8\ Al\ Ca.\end{matrix}\right\}$

Lawrencite, $Fe\ Cl_2$.

Readily prepared in the laboratory, but rapidly oxidizes, hence probably its non-occurrence in nature under ordinary conditions.

Magnetite $(Fe\ O_2)_2\ Fe$.

Maskelynite $[Si\ O_3]_4\ Al_2\ (Ca\ Na_2\ K_2)$.

Crystallizes in the cubic system.

Oldhamite, $Ca\ S$.

A readily oxidizable body, not occurring in nature under ordinary conditions.

Olivine, $Si\ O_4\ (Mg,\ Fe)_2$.

Osbornite.

? An oxysulphide of Titanium and Calcium.

Pyrrhotite, $Fe_{11}\ S_{12}$.

Rhabdite, $Fe_7\ P$.

Reproduced by passing the vapour of Phosphorus over red-hot iron-wire. Crystallizes in the quadratic system.

Schreibersite, ? $(Fe\ Ni\ Co)_3\ P$.

Troilite, $Fe\ S$.

Apparently identical with the product obtained by heating together iron and sulphur. Crystalline form not determined.

Trydimite, $Si\ O_2$.

Trydimite is a form of silica not produced in presence of water (as quartz), but by igneous fusion.

Graphite.

Alloys of Nickel and Iron.

Hydrogen, nitrogen, carbonic acid and carbonic oxide as occluded gases.

Certain soluble salts, occasionally, as the chloride and sulphate of sodium, and the sulphates of calcium and magnesium.

The first information as to the mode of formation of the minerals occurring in Meteorites was afforded by the researches of Dr. Sorby. He made use of the method of studying the *inclusions* which may be seen in crystals when examined in thin section under the microscope, a high power being generally used (*Q. J. Geol. Soc.*, 1858). By the study of artificially produced crystals, he established the following facts:—

1. That when substances crystallize out from aqueous solution portions of the liquid are included in the crystal, forming liquid cavities or inclusions. If the crystallization take place at a high temperature the liquid on cooling contracts, leaving what is generally termed a gas bubble. This bubble is free to move. Sometimes the bubble is vacuous, sometimes it contains a gas such as carbonic acid found in the cavities in quartz.

2. When the nature of the liquid magma, from which a substance crystallizes is such that it solidifies at the

ordinary temperature of the air, the appearance of the inclusions is very different. Thus silicate of iron, which frequently crystallizes out from the molten slag of copper works, shows *glassy* inclusions with *stationary* bubbles. Sometimes there is more than one bubble, which could not be the case with a liquid inclusion. In the case of a glassy inclusion with a bubble, the magma has cooled and contracted, leaving a bubble, and solidification has ultimately taken place, whereby the bubble has become fixed. If, however, the whole crystal be heated the included slag melts, the bubble becomes movable, and generally disappears when the temperature has been raised to that at which crystallization took place, the liquid having now expanded so as to occupy the whole of the cavity.

3. Crystals of other substances show *both* glassy inclusions and inclusions containing water. In such cases the temperature of formation was high, since the now solid magma was then liquid, and the crystallization must have taken place under great pressure, otherwise the water found in the liquid inclusions would have been in the state of vapour.

4. Lastly, in crystals formed by sublimation (*i.e.* where the substances change at once from the gaseous to the solid state without passing through the intermediate condition of a liquid), the inclusions are stationary gas bubbles bounded by the actual substance of the crystal itself.

The type of inclusion serves therefore to show by what process the crystal was formed. The processes obtaining in the formation of the crystals occurring in eruptive rocks and in mineral veins are—1. Formation from aqueous solution. 2. From igneous fusion. 3. The last two combined, which can only happen under great pressure. 4. Formation by sublimation. In studying the inclusions in the minerals of Meteorites, Dr. Sorby found glassy inclusions *only*, neither liquid nor gaseous inclusions being observed. This would appear to show that the Meteorites examined were formed by the process of igneous fusion pure and simple. This conclusion was confirmed in 1866 by Daubrée (*Géologie Experimentale*). His reproduction by the method of igneous fusion of rocks showing many of the characteristic minerals of Meteorites has been referred to in a former article (KNOWLEDGE, *July*, 1891). The brecciated structure of Meteorites, indicative of violent mechanical disturbance or of the agglomeration of heterogeneous fragments, was of course not shown by the products of the crucible. It is principally in such peculiarities of structure and of mode of aggregation of minerals that Meteorites differ from some of the more basic eruptive rocks, such as the diamond-bearing rock of Kimberley. Most nearly approximating to the siderolites and aerolites are the so-called volcanic bombs which are floated up with the liquid lava in eruptions, probably from great depths below the earth's surface.

Till recent years native iron was believed to occur only in Meteorites, and the constant association of the metal with nickel was regarded as another peculiarity of these bodies. It has, however, now been shown pretty conclusively that the native iron, found in large masses by Nordenskiöld in the Island of Disco, are of telluric origin, having in all probability been left by the weathering away of the basalt which occurs in the locality. This basalt, which belongs to the class of the more basic rocks, is found to contain nodules or balls of iron, sometimes nearly three-quarters of an inch in diameter. This iron (as in Meteorites) is alloyed with nickel, and shows the Widmanstätten figures. It is still undecided whether the basalt contained the metallic matter when in the molten condition before eruption, or whether the presence of the free metal is due to the reduction of silicate of iron by passage through beds containing carbonaceous matter such as are found in the vicinity.

According to a theory which is advocated by more than one eminent astronomer, Meteorites are *bombs* of ancient terrestrial volcanoes, shot into space in bygone ages, and revolving round the sun in orbits intersecting that of the earth, and hence one by one encountering the earth, of which they thus become once more a part. This theory of the origin of Meteorites has many points of advantage over those which refer them to the action of volcanoes on other members of the solar system. One point only will be mentioned here—namely, that of bodies shot out from any other planet, only an exceedingly small proportion would intersect the orbit of the earth, whereas bombs from a terrestrial volcano would *all* intersect this path.

Notwithstanding the ability with which this theory has been advocated, the view is still generally held that Meteorites come from the further realms of space, moving in cometary orbits, either parabolic or elongated ellipses. It is true that trustworthy determinations are wanting of the velocity of Meteorites in the highest regions of the atmosphere, determinations which would probably furnish conclusive evidence on this point; but the paths which Meteorites follow appear to be cometary rather than planetary, in that they do not show any definite relation to the ecliptic. Several cases have been known of the fall of Meteorites during a shower of shooting stars, though they have not been satisfactorily traced to the radiant of the shower.

The question of the existence elsewhere than on our own planet of the conditions necessary to life, as life is known to us, is a subject which cannot fail to excite interest. The mineralogical examination of Meteorites has confirmed the evidence of the spectroscope, that carbon, the element which appears essential to life on the earth, is present elsewhere than on our own planet.

SWIMMING ANIMALS.

By R. LYDEKKER, B.A.Cantab.

(*Continued from page* 154).

WITH the Fishes, which, with the exception of the Whale, are perhaps, of all animals, the most beautifully adapted for rapid motion through the water, we enter the great group of Vertebrates. The contour of an ordinary fish, such as the Perch (Fig. 3), is modelled on those lines suited for cleaving the water best, through which

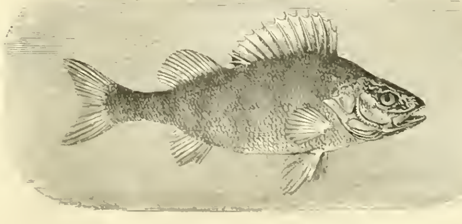


FIG. 3.—THE COMMON PERCH.

the fish is propelled mainly by the muscular tail with its terminal fin. The fins on the body act mainly as balances, although aiding to a certain extent in propulsion. These body-fins in all fishes are of two types, namely—paired and median. The number of paired fins is two, the front pair corresponding with the fore limbs, and the hinder pair with the hind limbs of quadrupeds. In the Perch (Fig. 3), the front or pectoral pair of fins are seen immediately behind the head; the second or pelvic pair being placed below and slightly behind the pectoral ones. In many other fishes (as in Fig. 4) the hinder pair of fins

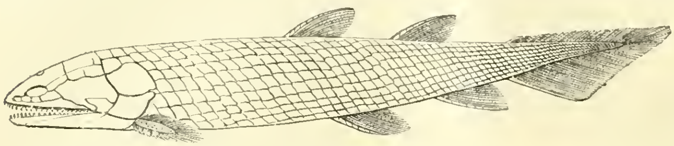


Fig. 4.—An Extinct Ganoid Fish.

occupy, however, a position corresponding with that of the hind limbs of quadrupeds. The pectoral fins, although assisting to a certain extent in the motion of the fish through the water, act rather in directing its course than as propellers. Their chief function is, however, to maintain the balance of the body in the water; a fish which has lost one of these fins falling over to the opposite side. It will be observed from Fig. 3 that the pectoral fin of a Perch (as well as of most of our existing fishes) consists of a number of rays spreading out in a fan-like manner from the point of attachment to the body. A totally different arrangement obtains, however, in the pectoral fin of the extinct fish represented in Fig. 4. Here it will be seen that the fin consists of a central lobe covered with scales, from the edges of which the fin-rays project as a deep fringe. This more primitive type of fin is indeed very common among the extinct fishes of the Palæozoic rocks, and still persists in the Barramunda of the Queensland rivers, a figure of which was given in the article on "Mail-Clad Animals." The more important median fins are the dorsal on the back, and the anal in front of the tail. In many fishes (Figs. 3 and 4) there are two dorsal fins, one in front of the other; the front one being often large and spiny, and the hind one small and soft (Fig. 3).

The tail and tail-fin form, as we have said, the chief propeller of the fish; and it will be particularly noticed that the position of this fin is vertical. In swimming, as we may observe in an aquarium where fish are kept, the tail is rapidly and strongly bent from side to side, while the two lobes of its fin have an undulating motion, and thus act like the blades of a screw-propeller. A difference between the structure of the tail-fin in the two figured fishes recalls the one already noticed in the pectoral fin. Thus in the Perch (Fig. 3) the scaly part of the tail ends in an abrupt and almost straight edge, from which the rays of the fin form a nearly symmetrical fork. In Fig. 4, on the other hand, the scaled part of the tail is produced to a point, extending far back among the fin-rays, which are arranged unsymmetrically along its two edges. It is this latter mode of arrangement which is the older and more primitive.

In certain fishes which depart more or less widely from the ordinary form there is a corresponding modification in the shape and functions of the fins. For instance, the Rays swim almost entirely by the aid of the greatly expanded pectoral fins, which have an undulating motion very similar to that of the median fins of ordinary fishes. On the other hand, in the Flying Fishes (see "Flying Animals," Fig. 2) the pectoral fins are enormously elongated, so as to act as organs of spurious flight. Again, snake-like fishes, as the Eel, swim by lateral curvatures of the body, in the so-called serpentine manner.

The only other Vertebrate animals which breathe by means of gills, and can therefore be regarded as primitively aquatic, are the young, or larvæ, of the Amphibians (Frogs, &c.). The young Tadpole, as we all know, is an ugly, large-headed creature, swimming by means of lateral movements of its tail. This tail has a vertical fin-like expansion, differing, however, from the fins of fishes by the absence of the bony or cartilaginous rays found in the latter. We have already alluded to the remarkable metamorphosis undergone by the Tadpole, in the course of which the tail is lost, the gills are replaced by lungs, and the limbs developed. The adult Frog is an instance of an animal adapted to live partly on land and partly in the water, swimming powerfully in the latter element by the strokes of its long hind legs, of which the toes are fully webbed. The Tailed Amphibians, such as the Newts and Salamanders, are less specially modified than the Frogs, and may be completely aquatic. All the Newts and Salamanders, including the purely aquatic Giant Salamander of Japan, lose, however, their gills in the adult state; but these are permanently retained in the curious blind Proteus of the caverns of Carniola.

Among the true reptiles of the present day (all of which breathe by means of lungs during the whole of their existence) there are three groups among which aquatic forms occur. The first of these includes the Crocodiles and Alligators, which swim by means of their long tail and limbs. Although thoroughly at home in the water, where they spend a large portion of their time, the organization of these animals has not been so modified for the exigencies of an aquatic life as to depart to any great extent from the normal type. The same remark will apply with still more force to our Common Snake, which is an expert swimmer. In the Sea-Snakes, however, which pass the whole of their life in the tropical seas, the tail assumes a vertically compressed and paddle-like form, and is thus as efficient a propeller as the tail of a fish. These snakes always swim on the surface of the sea, but it is very doubtful if they can have given rise to the stories of the Sea-Serpent.

Among the Chelonians the Marine Turtles have been especially adapted for an aquatic life by the modification of their limbs into oar-like paddles; although it is quite clear that this structure is an acquired one. The Soft Turtles (Trionyces), of the rivers of the warmer regions of the globe, are almost equally good swimmers, although their feet, with the exception of being webbed, retain the ordinary type of structure. The Pond-Tortoise, now restricted to Southern Europe, although occurring in the superficial deposits of this country, is almost equally aquatic. Indeed all Tortoises (except perhaps the gigantic ones of the Galapagos and Mascarene Islands) are excellent swimmers, and thus afford a good instance of how some members of a group have gradually adapted themselves to an almost completely aquatic life.

If, however, the Turtles have been specially modified for an aquatic existence, still more markedly is this the case with the extinct Ichthyosaurs or Fish-Lizards (Fig. 5). Since the structure of these reptiles has been fully noticed in a separate article, we need only allude here to the peculiar pavement-like structure of the bones of

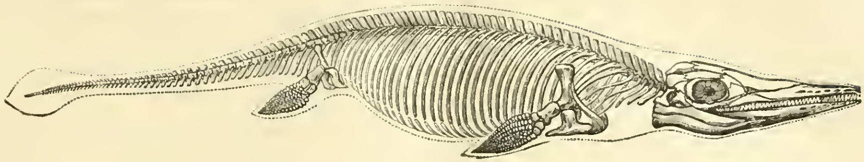


Fig. 5.—Skeleton of an Ichthyosaur.

the paddles; this being the extreme modification which limbs have undergone for the purposes of an aquatic life. Since, as shown by the absence of gills and the indications of remnants of a horny covering to the body, there is abundant evidence that the Ichthyosaurs are descended from land animals, they occupy a position among Reptiles precisely analogous to that held among Mammals by the whales of the present epoch.

The long-necked Plesiosaurs, to which a special article in Knowledge has likewise been devoted, were reptiles equally well adapted for an aquatic existence, but in which the modification of the limbs into paddles had not been carried to the same degree as in the Ichthyosaurs. The evidence for the derivation of the Plesiosaurs from terrestrial reptiles is even fuller than in the case of the group last mentioned.

Before taking leave of the reptiles we have to allude to another totally different assemblage of extinct aquatic forms, which were much more closely allied to the existing Lizards, and many of which were of gigantic dimensions. These creatures are generally known as the Mosasaurs, and were first brought to notice during the last century, when a huge skull was obtained from the upper Cretaceous beds of Maastricht, on the Meuse; the Latin name of the group being taken from that river.

These Mosasaurs, of which a large number of kinds are now known, differ from the Ichthyosaurs and Plesiosaurs in that the joints of their backbone, instead of having both front and back surfaces either deeply cupped or nearly flat, had cup-and-ball articulations, the cup occupying the front surface. This type of structure is common to existing Crocodiles and Lizards; but whereas in the former the ribs articulate with the joints of the backbone by means of long transverse processes jutting out from them, in the latter the ribs articulate directly with the aforesaid joints. Now the Mosasaurs have the latter mode of articulation, and, since they agree with the modern Lizards in the structure of their skulls, as well as in many other points of their bony anatomy, there can be no hesitation in regarding them as a group descended from the ancestral Lizards which have taken to an aquatic mode of life.

The Mosasaurs are confined to the Cretaceous epoch, and thus lived side by side with the Ichthyosaurs for the greater part of their term of existence, although they attained their maximum development in the very highest Cretaceous beds when the Ichthyosaurs and Plesiosaurs seem to have disappeared. For a short time, then, these creatures appear to have been the only gigantic marine Vertebrates, filling up the gap left by the disappearance of the Ichthyosaurs, which had not yet been occupied by the Whales. They were of carnivorous habits, as shown by their formidable teeth, and, like all groups of Vertebrates which have taken to a marine life, far exceeded in dimensions any of their terrestrial cousins, the length of some of the species being as much as forty feet.

We come now to the Birds, several groups of which are exclusively composed of species specially adapted for an aquatic life. Swimming birds, as a rule, support themselves on the surface of the water, taking occasional dives of longer or shorter duration, and, therefore, have no need to make any especial arrangements for breathing. They swim by using their legs as oars, the feet being webbed, and the toes folding up as the foot is brought forward after one stroke to prepare for a second. As we shall see, however, some species aid their swimming with their wings. All birds that swim have relatively short legs, which are generally placed far back on the body, since this position gives the maximum power in propelling the animal through the water.

There are five chief groups of swimming birds, namely, the Ducks, Geese, and Swans (Anseres); the Pelicans, Cormorants, and Darters (Steganopodes); the Gulls and Petrels (Gaviæ); the Divers, Auks, and Grebes (Pygopodes); and the Penguins (Impennes). There are, however, a few members of other groups, such as the Dipper among the Passerines, and the Coot among the Rails, which are also expert divers and swimmers. The circumstance, however, that in neither of these instances is the foot fully webbed—that of the Dipper being like the foot of a Thrush, and that of a Coot (Knowledge, Oct., 1890, p. 236) only having web-like expansions on the sides of the toes—indicates that the habits of these birds are of comparatively recent acquisition, and have not induced any strongly-marked structural peculiarities.

The Anseres include by far the greater number of swimming birds, and the admirable adaptation of their form and structure to their mode of life is so well known as to require no further mention. The Pelicans and their allies differ from that group in that the web includes all the four toes of the foot (Fig. 6), instead of only the three front ones. In this group the Frigate Bird has a shorter leg than any bird of equal size. The Darters, or Snake-Birds, of which there are four species found in the warmer regions of the globe, and of which examples are generally to be seen in the Zoological Society's Gardens, are, however, those members of the group most interesting from our present point of view. These birds are found in fresh waters, and swim with the whole of the body submerged, so that only the head and upper part of the long and flexible neck are exposed. In this position they look not unlike snakes swimming on the water, when seen from a little distance. It does not appear that any use of the wings is made in swimming. The Gulls and Petrels, in which the hind toe of the foot is not included in the web, have longer legs than most swimming birds, and the legs themselves are placed nearer the middle of the body. Since these birds

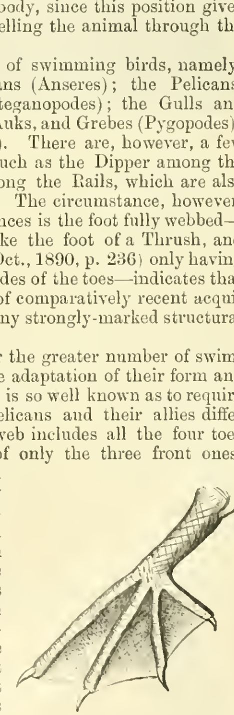


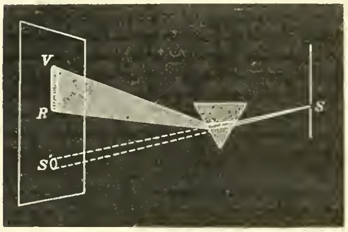
Fig. 6.—Webbed Foot of a Pelican.

depend mainly upon their powers of flight for obtaining their food, most of them only make use of the surface of the water, upon which they float placidly, as a resting-place (*To be continued.*)

ON THE RHYMICAL GROUP OF HYDROGEN LINES VISIBLE IN MANY STELLAR SPECTRA.

By A. C. RANYARD.

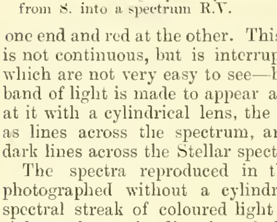
As all readers of KNOWLEDGE know, a prism or wedge-shaped piece of glass breaks up a beam of white light into a series of coloured beams arranged fan-wise, the blue or violet rays being turned through the greatest angle. If such a prism be placed in front of a telescope, so as to send the refracted rays from a star down the axis of the telescope, an observer looking in at the eye end will see the image of the star spread out into a narrow line of light, blue at one end and red at the other. This narrow band or spectrum is not continuous, but is interrupted by small dark gaps, which are not very easy to see—but if the narrow spectral band of light is made to appear a little broader by looking at it with a cylindrical lens, the dark gaps become visible as lines across the spectrum, and appear similar to the dark lines across the Stellar spectra shown on the plate.



Prism breaking up a ray of white light from S. into a spectrum R.V.

The spectra reproduced in the plate were, however, photographed without a cylindrical lens. The narrow spectral streak of coloured light was turned so as to be at right angles to the direction of the star's diurnal motion, and by slowing the driving clock of the telescope the spectral streak was caused to sweep across the sensitive plate in a direction at right angles to its length, thus producing a trail or trace with dark lines across it, corresponding to the dark gaps in the spectral streak. The upper four Stellar spectra on the plate are from photographs kindly given me by the Brothers Henry, and the lower four are copied from photographs published by Prof. E. C. Pickering in connection with the spectroscopic work of the Draper memorial.

The method of observing Stellar spectra with a prism in front of the object-glass, and a cylindrical lens, was devised by Fraunhofer—nearly 80 years ago—in 1814. This remarkable man* turned a telescope with a prism in front of the object-glass to the stars, and noted some of the chief variations in their spectra. He found that the spectrum of Pollux closely resembled the spectrum of our Sun, while there were recognizable differences in the spectra of Capella, Betelgeuse and Procyon—they were all crossed by narrow dark lines, some of which he identified with solar lines. On the other hand, the spectra of Sirius and Castor were seen to be of a different type, and to be crossed by three massive dark bars, two in the blue and one in the green.



Prism in front of Object-glass.

After a lapse of 45 years Prof. Kirchhoff, of Heidelberg, found a key which enabled him partially to read the hieroglyphic language of the Fraunhofer lines, but much more remains still undeciphered until some Daniel shall arise who can interpret the story clearly written in letters of light upon the heavens. Kirchhoff passed a beam of sunlight across a space occupied by burning sodium vapour, and perceived with astonishment that the dark Fraunhofer line D, instead of being blotted out by the luminous rays of the same refrangibility as that given out by the flame, were rendered blacker and thicker by the superposition. He tried the same experiment, substituting the continuous spectrum derived from the light of a Drummond lamp for sunlight, but a dark line, corresponding in every respect to the solar D line, was seen to cross the spectrum. The inference was irresistible that these dark lines were produced by absorption of light corresponding in wave-length to the bright lines given out by the vapour, and that there must be an absorbing layer of sodium vapour about the Sun. This discovery was quickly followed up by the examination in the laboratory, by Prof. Kirchhoff, of the bright lines from other incandescent metallic vapours, and many of the bright lines from such vapours were identified with dark lines in the Solar spectrum. But in spite of all the work done by Prof. Kirchhoff and his assiduous pupil, Dr. Bunsen, and in spite of all the careful measuring and photographing of the lines in the spectra of terrestrial elements since their day, not one-fourth of the dark lines of the Solar spectrum have as yet been identified with lines in the spectra of terrestrial elements; and there are many mysterious discrepancies between the spectra of the elements, as observable under laboratory conditions, and the corresponding dark lines of the Solar spectrum. We are, therefore, very far from having read the riddle of the Solar spectrum, and we are much further from having learnt all that may be deciphered from the spectra of the stars.

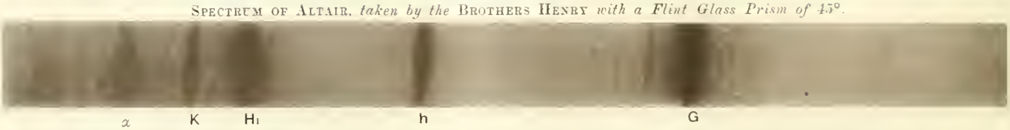
Soon after the publication of Kirchhoff's and Bunsen's results, Father Secchi set himself to the task of making a spectroscopic survey of the heavens. He examined the spectra of 4000 stars, and grouped them into four great classes, with the first of which we are at present more especially concerned. It contained Sirius and Vega, and more than half of the stars, which he examined. Their spectra are characterized by the great strength of the hydrogen lines, which are wide, hazy bands, much like the H and K of the Solar spectrum, though these lines in the Solar spectrum do not belong to hydrogen but to calcium, an element which is closely associated with hydrogen in the Solar prominences, but it is very different from it in atomic weight and chemical qualities.

* Fraunhofer greatly improved the achromatic telescope. He succeeded, after many experiments, in making the first large achromatic object-glass of high quality and finish. It was secured by the elder Struve for the Russian Government, and was long known as the "great Dorpat refractor," though it was only 9½ inches in diameter, and was of 14 feet focal length. He discovered nearly a thousand lines in the Solar Spectrum, and mapped 576 of them, naming the principal ones by the letters of the alphabet. He recognized the double D line in many Terrestrial Spectra, and noted the identity of its place with the solar D lines, though the true interpretation of the coincidence was not recognized for more than 40 years after he had laid such ample foundations for the deductions of modern spectrum analysis. After many ingenious experiments, he succeeded in making a diffraction grating, which showed him the lines in the normal spectrum.

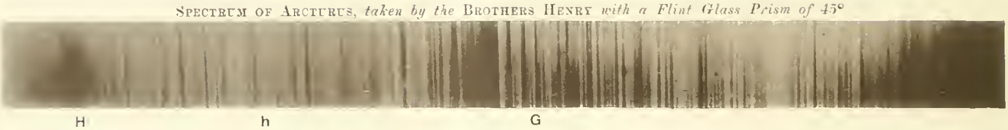
Spectrum of Vega, *taken by the* Brothers Henry *with a Crown Glass Prism of 22°.*

Spectrum of Vega, *taken by the* Brothers Henry *with a Flint Glass Prism of 45°*

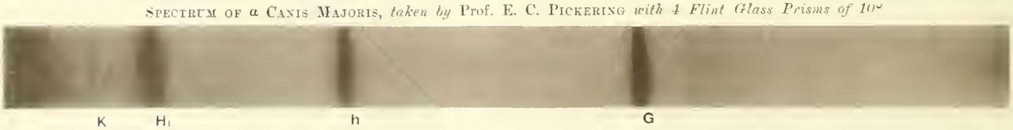
Spectrum of Altair, *taken by the* Brothers Henry *with a Flint Glass Prism of 45°.*



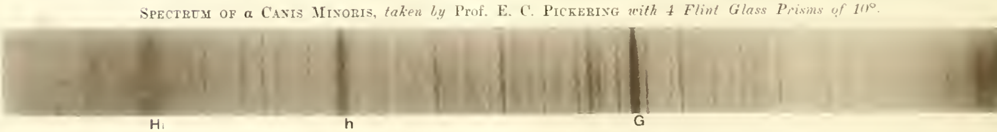
Spectrum of Arcturus, *taken by the* Brothers Henry *with a Flint Glass Prism of 45°*



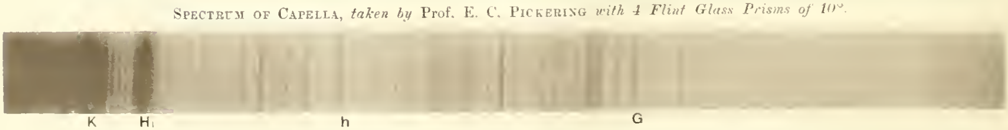
Spectrum of α Canis Majoris, *taken by* Prof. E. C. Pickering *with 4 Flint Glass Prisms of 10°*



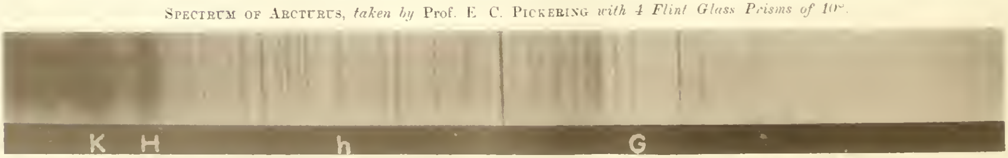
Spectrum of α Canis Minoris, *taken by* Prof. E. C. Pickering *with 4 Flint Glass Prisms of 10°.*



Spectrum of Capella, *taken by* Prof. E. C. Pickering *with 4 Flint Glass Prisms of 10°.*



Spectrum of Arcturus, *taken by* Prof. E. C. Pickering *with 4 Flint Glass Prisms of 10°.*



The Automatic Engraving Company, Limited,
Strode Road, Willesden Green.

In the spectra of the stars of Secchi's first type the K line is generally faint, and it is sometimes entirely absent.

As early as 1863 Dr. Huggins attempted to photograph the spectrum of Vega, and succeeded in getting an impression of the spectrum, but without any of the lines. In 1872 Dr. Henry Draper, at Dobbs's Ferry, on the Hudson, succeeded in obtaining a photograph of the spectrum of Vega, showing, for the first time, four of its hydrogen lines.* The introduction of more sensitive dry plates in 1876 induced Dr. Huggins to turn again to the photography of Stellar spectra, and he soon succeeded in obtaining pictures showing many lines.

In a paper published in the *Philosophical Transactions* for 1880 on "The Photographic Spectra of Stars," he called attention to the arrangement of twelve strong lines in the spectrum of Vega. Remarking that the group possesses a distinctly symmetrical character, as the refrangibility increases the lines diminish in breadth, and the distance between any two adjacent lines is less; and he hazarded the suggestion that the lines must be "intimately connected with one another and present the spectrum of one substance."

Two of them may be seen in our reproduction, though they are very faint, and only just visible. There is a spot on the line ι, corresponding to a flaw on the negative of the Brothers Henry, which will enable the line ι to be easily identified, and the two faint lines will be seen beyond it, making in all sixteen‡ lines which can be counted on our reproduction.

All the lines of the group are of the same character, that is to say, they are broad and winged at the edges, and they become less intense and better defined in the order of their refrangibility. At the date of Dr. Huggins' paper in 1880, the lines of the hydrogen spectrum had only been photographed in the laboratory as far as δ, and their wave-lengths as given by Dr. H. W. Vogel corresponded within the limits of probable error with the wave-lengths of the typical lines measured by Dr. Huggins.

Vogel's numbers.		Dr. Huggins' numbers.
H	λ 3968	λ 3968
α	3887	3887·5
β	3834	3834
γ	3795	3795
δ	3769	3767·5

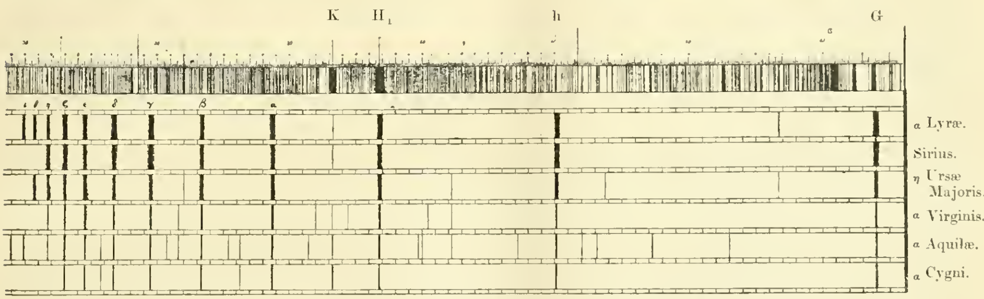


Diagram showing the relative intensity of the lines of the Hydrogen Spectrum in six Stellar Spectra, photographed by Dr. Huggins, copied from his paper on the Photographic Spectra of Stars in the *Phil. Trans.* for 1880.

In this paper Dr. Huggins designates the nine most refrangible of the twelve lines photographed by him by the Greek letters, α, β, γ, &c, ι being the last one seen on his photographs. He adds: "A circumstance of great importance is the entire absence of any lines in the spectrum beyond ι. The spectrum, which then becomes continuous, is strong, and extends beyond S in the ultra violet. In solar photographs, taken with the same apparatus, the lines in this region are well defined for some distance beyond S, and therefore this abrupt cessation of lines cannot be referred to an instrumental cause."

Dr. Huggins seems to have thought it strange that the group of lines was not continued further, and that if the lines belonged to a degrading series, and were due to a common physical cause, the group ought not to end abruptly at ι. His suspicion has been confirmed, for the photograph of the Brothers Henry, from which the uppermost spectrum on the plate has been copied, shows at least† three more lines on the more refrangible side of ι.

On the strength of this evidence, Mr. Johnstone Stoney wrote in a note published with Dr. Huggins' paper:—

"There can remain very little doubt that your typical lines are due to hydrogen. The evidence of their all being members of one physical system is made very plain when their positions are plotted down, for it then becomes conspicuous that they lie on, or very near a definite curve, which could not happen by chance.

"This question of whether they lie actually on, or only near a definite curve is, if I mistake not, of very great significance in the theory. If they lie *on* a curve obeying any exact mathematical law their connection must, I think, be attributed to their corresponding to the *consecutive* partial tones of some vibrating system (like those of an elastic rod or bell, for example). If, on the other hand, they lie near but not on the curve, this circumstance would support the hypothesis that the visible lines are members of harmonic series, most of the members of which are invisible, those only being seen whose positions chance nearly to fulfil a definite condition."

Mr. Johnstone Stoney converts Dr. Huggins' wavelengths into wave-frequencies in air, and comes to the conclusion that assuming that the irregularities in the second differences cannot be referred to errors of observation, the positions of the lines *do not lie on but lie near to a definite curve.*

* The photographic record of Dr. Henry Draper, and his father, Dr. J. W. Draper, is very remarkable. The father, nearly half a century ago, obtained the first photograph of a human being, as well as the first photograph of the Solar spectrum, and the son obtained the first photograph of a nebula (the Orion nebula, which was photographed by him on the night of the 30th September, 1880), as well as the first photograph of a Stellar spectrum showing lines.

† Prof. Geo. E. Hale, with whom I have had the advantage of examining the photographs given me by the Brothers Henry, pointed out four lines beyond Dr. Huggins' line ι, and thought that he saw a suspicion of a fifth line.

‡ This includes the K line, which does not belong to the hydrogen spectrum, and the F line, which was not shown in Dr. Huggins' photograph.

He then points out that the wave-lengths of H and the line near G are connected harmonically, being exactly the 35th and 32nd harmonics of a vibration whose fundamental is $\frac{\tau}{72{\cdot}003}$ when τ is the time in which light travels a millimetre in air—a connection which is rather far fetched and unsatisfactory.

One of the most remarkable facts with regard to the vibrations of molecules which become visible to us as lines in the spectrum is that no simple harmonics are observed. Very good photographs of the solar spectrum have been taken, extending from above wave-length 3000 tenth-metres to below wave-length 8500 tenth-metres, but no repetitions of the lines and groups of lines are found to exist at positions in the spectrum corresponding to double the wave-length, or at two-thirds or any other simple multiple of the wave-length, as would probably be the case if a molecule was constituted like a bell or a tuning-fork, and gave out overtones corresponding to the chief vibrations with which it was pulsating.

Much interest naturally attaches to any relations that may be noted between the wave-lengths given out by an element, as they may teach us something with regard to the internal architecture of molecules. The strange groups of lines in the Solar spectrum and the numerous similar pairs and triplets indicate that there must be many such co-related lines, but the exact law of relationship needs to be worked out and traced back to its probable physical cause.

Some slight advances have been made in this direction. Prof. Hartley has called attention to a most remarkable relation connecting the lines in the series of triplets in the spectra of magnesium, zinc and cadmium. He corrected the wave-lengths for atmospheric refraction and then calculated the wave-frequency, and found that the differences of these frequencies for each triplet in any one series is a constant quantity within the limits of probable error of the observations used. That some such relation exists between the wave-lengths of the lines of the hydrogen spectrum was evident from the date of the publication of Dr. Huggins' paper.

In 1885 J. J. Balmer* gave a formula for connecting the wave-lengths of this group of lines of the hydrogen spectrum which approximately agreed with the positions of the lines as then known, and subsequent observations have shown that the formula is remarkably accurate. Balmer's formula is

$$\lambda = 3647{\cdot}20\ \frac{m^2}{m^2 - 4}$$

where m takes in succession the values 3, 4, 5, &c. The value of λ, given by making m equal 3, corresponds to the wave-length of the C line; m = 4 gives the wave-length for the F line, and so on.

Prof. J. S. Ames, Assistant in Physics at John Hopkins University, has, in a very important paper published in the *Phil. Mag.* for July, 1890, given an account of his verification of this formula. Cornu † and Hasselberg ‡ had already examined the spectrum of hydrogen in the laboratory, under various conditions of electrical tension, and had succeeded in getting all the lines of the Stellar series as far as θ, as well as many other lines which are spoken of as belonging to the "secondary" spectrum of hydrogen. Prof. Ames repeated their experiments, taking every precaution in the measurement of the positions of the lines, and his places agree remarkably well with Balmer's formula when they are corrected so as to correspond with the refractive indexes in vacuo. Prof. Ames remarks that he was entirely unable to obtain the Stellar series of lines by itself, although he says "I am confident my hydrogen was pure and I varied the tubes, the current, the vacuum, and the exposure. I also introduced large condensers without any noticeable change." We therefore do not seem at present to be able to imitate in the laboratory the conditions under which hydrogen exists in stars having the first type of spectra, and the same remark applies to nearly all the spectra of elements recognizable in the Solar spectrum.

The accuracy of Prof. Ames' measures are confirmed by

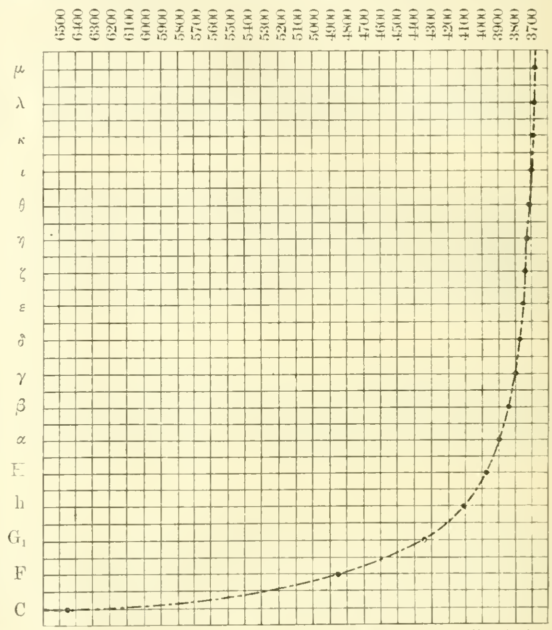


Diagram illustrating the relation of the Wave-Lengths of the Stellar Series of Lines in the Spectrum of Hydrogen.

their agreement with Prof. George Hale's measures of the positions of the hydrogen lines in the Solar Prominences, which are given below.§ There is some slight doubt

* *Wied. Ann.* xxv. 1855.

† *Jour. de Phys.* [10] v. 1886.

‡ *Mém. de l'Acad. Imp. St. Pétersb.*, xxx. p. 7 (1882), xxxi. p. 14. *Bull. de l'Acad. Imp. St. Pétersb.* xi. p. 203 (1884).

§ Positions of lines in the hydrogen spectrum as measured by

	AMES.	HASSELBERG.	CORNU.	HUGGINS.	HALE.
C	6563·04				
F	4861·49	4860·60			
G_1	4340·66	4340·06	4339·5		
h	4101·85	4101·18	4101·0	4101·0	
H	3970·25		3968·9	3968·9	3970·11
α	3889·15		3887·8	3887·5	3889·14
β	3835 6		3834·5	3834·0	3835 54
γ	3798 0		3796·9	3795·0	3798·1
δ	3770·7		3769·4	3767·5	3770·8
	3750·15		3749·3	3745·0	
ζ	3734·15		3733·6	3730·0	
η	3721·8		3720 6	3717·5	
θ	3711·9		3710·7	3707·5	
ι				3699·0	

about the proper correction for atmospheric refraction, but using the numbers adopted by Prof. Ames, we have

Places calculated $=3647{\cdot}20\ \frac{m^2}{m^2-4}$.	Places observed by Ames, corrected for atmospheric refraction.
C 6564·96	6564·97
F 4862·93	4862·93
G_1 4341·90	4342·00
h 4103·10	4103·11
H 3971·4	3971·40
α 3890·3	3890·3
β 3836·7	3836·8
γ 3799·2	3799·2
δ 3771·9	3771·9
ε 3751·4	3751·3
ζ 3735·6	3735·3
η 3723·2	3722·8
ϑ 3713·2	3712·9

The positions of the next three lines, ι, κ, and λ, calculated from Balmer's formula, are 3705·1, 3698·5, and 3692·9, which agrees very satisfactorily with the positions of the lines shown on the photograph of the spectrum of Vega given me by the Brothers Henry.

We may, therefore, feel some confidence that Balmer's formula corresponds to a physical fact, and that one series of tremors with which the hydrogen molecule vibrates when it is disturbed, are related so that the length of the waves produced, when plotted as in the diagram, fall upon a curve having an asymptote at wave-length 3647·20.

If m be made equal to 1 in the formula, we get an infinite value for λ; which indicates that there ought to be one line of the series forming the limit of the spectrum at the extreme red end. When m is made equal to 1, we get $\lambda = -1215{\cdot}4$. It would be interesting to determine whether this negative value of the wave-length may be interpreted as meaning a wave of opposite phase. If so, we should expect to find a line of the series at wave-length 1215·4, a region of the spectrum which has not yet been explored.

Notices of Books.

Popular Astronomy: A series of Lectures delivered at Ipswich by Sir George Biddell Airy, K.C.B., Astronomer Royal, revised by H. H. Turner, M.A., B.Sc., Chief Assistant Royal Observatory, Greenwich. These lectures of Sir G. B. Airy are a model of clear and simple exposition. They were delivered more than forty years ago (in March, 1847) to the members of the Ipswich Museum and their friends, and were, as Sir G. B. Airy explained at the time, intended to be understood by working men. That he succeeded in making the somewhat difficult and dry subjects that he dealt with interesting is attested by the fact that the book has passed through six editions, and that now a seventh is called for. The instruments used in observatories have so changed since the date when the lectures were delivered that Mr. Turner has had a difficult task in making the necessary alterations in the text without suggesting anachronisms or greatly altering the form in which the lectures were delivered, but he has done his work with great discretion, and has added some interesting notes. Amongst the many "Popular Astronomies" which have been written it would still be difficult to select a better book to give to young people whose interest in Astronomy is dawning.

Pictorial Astronomy. By G. F. Chambers, F.R.A.S.—Mr. Chambers has barely finished working upon his enlarged edition of the "Descriptive Astronomy," when he gives us another entirely new volume, intended for beginners in Astronomy. It is profusely illustrated, and contains a great deal of valuable information, with some useful tables and practical suggestions for those who meditate setting up a small observatory, but the drawings of observatories and instruments are mostly of very old-fashioned type. In fact all the illustrations are antiquated, and we recognize most of them as old friends, which have done yeoman's service in the teaching of Astronomy. But the strength of Mr. Chambers' books never lays in their illustrations.

Outlines of Field Geology. By Sir Archibald Geikie, F.R.S. Fourth edition. (Macmillan.)—Among the many works of this distinguished author, few are more welcome than this new and much enlarged edition of his well-known "Field Geology." Two lectures upon geological maps and instruments of surveying, delivered in 1876, and published in pamphlet form in the same year, were the source from which this book took its origin. In 1879 a second edition appeared in a more permanent shape, so much enlarged and re-cast as to constitute a new book, of which the present edition is a still further improved form. As the author says in the preface, his aim has been to write for the large body of readers who, though possessing some general acquaintance with Geology, find themselves helpless when they try to interpret the facts which they meet with in the field. Sir Archibald acts as a most interesting interpreter to them as they examine the rocks exposed in quarries, ravines, or sea-shores; and there can be no doubt that anyone who follows his instructions, and observes according to his rules, will find himself in a fair way to understanding the geological structure and history of the particular district in which he is interested. It is needless to say that the writing is clear and concise throughout. We have only space to refer to the more interesting parts of the book, and to those in which some of the most recent results of geological science are introduced. Beginners, who are usually rather hazy in their ideas of the different rocks composing the earth's surface, should carefully study the excellent chapter on the determination of rocks, if they wish to be saved from endless mistakes. The chapters on the tracing of boundary lines, and the unravelling of geological structure, contain many useful hints, the result of the author's wide experience in geological surveying. One of the best chapters in the book is that in which the igneous rocks, and their modes of occurrence, are described. In the chapter on schistose rocks and mineral veins, we find references to some very interesting recent discoveries about the sheering and crushing of rocks. The schistose rocks have been subjected to enormous pressure, and extensive deformation has taken place; thus, in some conglomerates the pebbles have been crushed and flattened, and even pulled out of shape, whilst their sandy or gravelly matrix has been converted into a schist. A crystallization of the crushed material has taken place along the planes of sheering or cleavage, thus causing foliation. Igneous rocks, too, have suffered in the same way. Dykes of basic rocks, such as basalt, have been changed into fissile hornblende schists! In chapter X., the wonderful thrust-planes in the north-west of Scotland are referred to. Some of the rocks of that district have been pushed for many miles over others.

Manual of Assaying. By Walter Lee Brown, B.Sc.; Revised, Corrected, and considerably Enlarged by A. B. Griffiths, Ph.D., F.R.S. (London: W. Heinemann. 1890.) Mr. Brown's manual, of which this work is a revised edition, is well known to practical assayers, though its reputation has probably been greater in the United States than in this country. Dr. Griffiths has improved the work in several respects, and has added an important chapter on Fuel. We could have wished that more use had been made of the great work by Dr. Percy, certainly a higher authority than Mitchell's manual, to which the author frequently refers; and perhaps some of the illustrations might with advantage have been replaced by new ones. One drawback with regard to the drawings representing instruments and apparatus is that they are not on anything like a uniform scale—no one could form a correct idea of the relative sizes of the things themselves from the woodcuts: *e.g.*, the hammer and anvil on page 69, and the cupel on page 63. The different processes employed by the assayer are carefully and clearly described, and the various possible causes of failure in obtaining trustworthy results are, in most cases, sufficiently indicated. Part I. deals with apparatus and re-agents, and is divided into three chapters, in which descriptions are given of the implements used for pulverizing, sampling, &c., scales and balances, weights, furnace tools; also wet and dry re-agents for assaying. Then follow descriptions of certain processes, such as the testing of lithage for silver, the testing of lead for silver, and the determination of the reducing and oxidizing of certain agents. These descriptions, which are thoroughly practical, are largely helped by numerous illustrations of apparatus and instruments. Perhaps the most valuable feature of the book is the way in which the numerical examples of assaying are worked out in several places in the body of the treatise itself and in the appendix. These will doubtless be appreciated by such students as may be endeavouring to prepare themselves by self-tuition for future practical work as assayers. We quote the following passage as an example to show the practical nature of the book: "Absolutely accurate assays of gold and silver bullion require care, skill, and first-class apparatus. The skill may soon be acquired by practice, but the apparatus must not only be of the best quality, but must be kept in the most perfect state of adjustment. It is not enough to purchase chemicals which are marked 'pure,' or a balance supposed to be accurate: the chemicals must be tested, and the accuracy and adjustment of the balance and weights verified, before correct results can be obtained." The appendix concludes with lists of the principal gold, silver, copper, and lead minerals, a list of useful books connected with the subject, a plan of a laboratory, outfit, tables of weights and assay ton equivalents.

Coal, and what we get from it: a Romance of Science. By Raphael Mendola, F.R.S. This very instructive little treatise is one of the "Romance of Science Series," published by the S.P.C.K., and the name of its author is sufficient guarantee for thoroughness and accuracy. Though some readers might perhaps be somewhat repelled at first by the long names given to carbon compounds, yet we think this prejudice will be overcome as they peruse its pages, and give place to a keen sense of delight as they follow the marvellous transformations so ably described by the author. The earlier chapters of the book contain a clear and interesting account of the origin of Coal, and of the energy stored up in it, illustrative of George Stephenson's celebrated statement about "bottled-up sunshine." This is followed by a sketch of the history of coal gas, together with an account of its manufacture as at present carried on. The author next takes up the subject of the commercial importance of the liquid and solid products resulting from the distillation of coal, viz.—the "ammoniacal liquor," the coke, and the tar. The second half of the book is, in fact, occupied with the history and description of the marvellous range of substances obtained, directly or indirectly, from coal tar. In the early days of gas manufacture, this black unsavoury residue was, in every sense, a "waste product," and the manufacturer was only too glad to get rid of it as best he could. Now it is made to furnish not only an almost endless variety of brilliant colours, but delicious essences and delicate perfumes, while immense fortunes have been realized by the fortunate discoveries of the processes by which such results have been obtained.

In 1828, Faraday discovered his "Bicarburet of Hydrogen" in the oil produced by the condensation of the so-called "oil-gas." In 1834, the same hydro-carbon was obtained by Mitscherlick by heating benzoic acid with lime, and since then it has been known in this country as benzol or benzene. In 1845, Hofman proved the existence of benzine in the light oils from coal tar, and in 1858, Perkin took out his first patent for a coal-tar colour under the name of "mauve." For the wonderful development of this branch of chemistry, and for an account of its extension to medicine, sanitary science, photography, and the arts, we must refer the reader to the book itself, which will well repay careful reading, and put him in possession of the latest processes and discoveries.

Prof. Max Wolf, of Heidelburg, has obtained some interesting photographs of the Milky Way, in the neighbourhood of α Cygnus, which we hope to reproduce in the October number.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

ON THE COMPARISON OF PHOTOGRAPHS OF THE MILKY WAY.

To the Editor of Knowledge.

Dear Sir,—In the letter on the above subject which appears in the May number of Knowledge, Mr. Barnard raises a question of great importance. The words used are, "I have no hesitation in attributing the difference between these pictures entirely to the development of the negative. As I have taken occassion to remark elsewhere, the utmost care must be exercised in the development of Milky Way pictures to bring out the cloud-forms clearly and strongly." This is a point that forced itself upon my notice as soon as I began taking photographs of the Milky Way, for the details in these pictures are often as delicate as a thin fog on the plate, and the slightest over-developing may suffice to produce such marks, which it is almost impossible to distinguish from features of the Milky Way. Indeed, I only know of one method of making sure which parts of the negative show faint Milky Way features and which are fog, and that is to multiply the pictures and compare them carefully. Now, my photograph of the Milky Way about α 17h. 58m. and δ 30°, which you reproduced in Knowledge for March last, is from one of eight negatives of this object which I have taken, and it is not the best so far as the nebulous part is concerned, but they all agree in

supporting the picture in March number of Knowledge as to the *relative brightness of the several parts* of the nebulous light. I think, therefore, there can be no doubt that my picture is right and Mr. Barnard's suffers from over-development. I have adopted the same method of making sure of the features in other parts of the Milky Way, and I am sure it is necessary where exceedingly delicate details have to be shown. When my photograph to which Mr. Barnard refers was taken, your reproduction of his of the same object was before me, and I saw the differences, which I was then disposed to attribute to the great advantage Mount Hamilton has in elevation, but Prof. Pickering's opinion of the advantage of a mountain station—that it only enables us to photograph stars $\frac{1}{3}$ of a magnitude lower—seems to make my supposition untenable, and to leave no alternative but that the difference is due to development, and I think over-development of the Mount Hamilton picture. Seed's plates are undoubtedly very good—I have used some of them, and I think highly of them—but they are not so sensitive as the Ilford plates, which I used for the pictures in question.

My experience leads me to the conviction that where extremely delicate details have to be caught, such as those in the Nubecula Major, the nebula about Eta Argus, and others, what is required is length of exposure rather than strong development. I have repeatedly tried the two methods, *i.e.*, long exposure and strong development, on the same object, and have no hesitation in saying that for delicate nebulous details the latter is to be decidedly avoided. Yours very truly,

Sydney Observatory, H. C. Russell.
July 6th, 1891.

[A close examination of Mr. Barnard's picture of the Sagittarius region referred to by Mr. Russell has convinced me that the nebulosity shown upon it really corresponds to areas of luminosity on the heavens, and is not a mere photographic fogging due to over-rapid development. There is an intimate connection between the dark areas on Mr. Barnard's photograph and the disposition of the stars which could not be due to chance, and the bright structures are altogether different in form from the patches in which fog shows itself on an over-developed picture. From my experience in reproducing pictures of nebulæ, I can fully confirm Mr. Barnard's statement that the density of the nebulosity and fainter cloud forms is very dependent on suitable development. It is to be regretted that circumstances have prevented Mr. Barnard from taking more photographs of this extraordinary region of the Milky Way. Mr. Russell has recently sent me some most interesting photographs of the η Argus Nebulæ and the κ Crucis cluster, which I hope shortly to reproduce in Knowledge. —A. C. Ranyard.]

THE OBSERVATION OF RED STARS.

To the Editor of Knowledge.

Dear Sir,—I have been considerably interested by a perusal of Miss Clerke's article, with the above heading, in the August number of Knowledge. With much of what is there stated I entirely agree; though, with all possible deference to the gifted authoress, I venture to dissent from her conclusions on one very material point, and that is—can the alleged variation of colour in certain stars be accepted as a demonstrated *fact*? A long experience of my own in observing star colours, as well as that resulting from the superintendence of such work by other observers, has made me extremely sceptical on this point; and I should require stronger evidence than we now possess to admit that such a conclusion was established. Casual star-gazers have no idea of the practical difficulties that beset this subject. Eyes differ so widely in their colour perceptions, that it is really not safe to accept the uncorroborated testimony of any one observer until it has been ascertained that his colour faculty is fairly normal. Neither can the differences arising from various kinds and apertures of telescopes be safely ignored: reflectors almost invariably give deeper tints than refractors, whilst any great difference in aperture has its corresponding effect. Then there is the atmospheric influence to be added to the account, and experienced observers know that this is a potent factor. The altitude of the star, the degree of darkness of the sky background, humidity and clearness of the air, etc.—if apparently trivial each by itself—will, combined, exercise some perceptible effect on the resulting colour. Therefore, I contend that the most satisfactory method of eliminating these errors—personal, instrumental, and atmospheric—is to take the *mean* of a large number of independent contemporaneous estimates by different observers, and accept that as the nearest probable approach to the true result. I would like to make a few remarks on the objects cited as examples of variation in colour:—

Espin-Birmingham, 352 (Schj. 148). The discrepancies in its assigned tint of redness are quite within the usual range of errors of observation, the large difference in the apertures of the telescopes used being alone sufficient to account for much of the discordance. The evidence for variation in magnitude does not seem very strong; indeed, it might reasonably be inferred that Birmingham's solitary observation of "no colour" belonged to some other star.

Es-Birm. 221 (Schj. 90). I think there is quite a possibility that these irreconcilable estimates relate to two different stars. According to the B.A. Catalogue (which formed the basis of my working list in 1877-8), there are two $6\frac{1}{2}$ mag. stars close together near this place —B.A.C. 2365 and 2369, otherwise 44 and 45 Camelopardi. Now the former of these agrees so closely with the position given for Es-Birm. 221, that it seems as if they must be synonymous; this was the object I observed as "$6\frac{1}{2}$ mag., orange red," with a 5 inch refractor. For the other one (32s. following and 13′ north), I could find no star larger than 8 mag. in its place, and as no colour was mentioned, it was presumably white. Possibly one or both of these stars may be variable in magnitude.

Birm. 118 (Schj. 63). This I noted in 1885, with $11\frac{1}{4}$ inch reflector, as "yellowish white." Perhaps there is some reason to doubt its identity, judging from the foot-note to the Dunsink observations, which suggests that the estimate probably belonged to another star closely preceding.

Es-Birm. 544 (Schj. 211). It does look as if there was some reason to suspect variation here, in magnitude if not in colour. But a more extended series of observations are required before the latter assumption can be legitimately entertained, as there is a gap of fourteen years between Espin's observation and the last recorded one preceding.

r Velorum does indeed appear to offer promising ground for further investigation, but, in the meantime, it would be wise to suspend judgment.

If suspected colour variables have been apparently neglected, it is because the evidence for variation is so slender that it finds but little acceptance in the astronomical world. We *must* be sure of the facts before proceeding to draw deductions from them—and the facts are scarcely established, as yet. In saying this, I am equally desirous of further investigation in the fascinating field of stellar chromatics, and think, with Miss Clerke, that the spectroscope is the most promising instrument to deal with the

problem. But it is, however, *possible* that two stars of similar colour might have different spectra, because there are several pairs of complementary tints which, when united, produce white light.

W. S. Franks.

SOME PRACTICAL APPLICATIONS OF ELECTRICITY.

By J. J. Stewart.

(*Continued from page* 33.)

II.—Secondary Batteries.

When a current of Electricity passes from a copper plate immersed in a solution of a copper salt, such as copper sulphate, to another plate opposite to it in the same solution, say one made of platinum, copper is deposited on the platinum plate owing to the decomposition of the solution, the amount of copper thus set free being proportional to the strength of the current which passes. Faraday was the first to prove this, and called the apparatus, consisting of the trough of solution and the plates dipping into it, a *voltameter*, because it served as a means of measuring the strength of currents. [I may say, in passing, that a voltameter on just the same principle as this is used by Edison to act as a current meter to indicate the quantity of Electricity sent from his electric light mains to any single house.] If an electric current is made to traverse a cell consisting of two plates of platinum placed opposite each other in acidulated water, the water is continuously decomposed into its constituent elements during the passage of the current, provided this current is above a certain strength; but whilst this operation goes on a remarkable phenomenon is noticed, the current which commences with a given strength becomes weaker and weaker, and if a galvanometer is placed in the circuit in order that the behaviour of the current may be observed, what is seen to happen is this—the galvanometer needle, when the current through the cell is first started, swings off vigorously and comes to rest at a certain angle of deflection, indicating the strength of the current, but, on further watching, it is seen to be creeping back; the deflection is gradually decreasing towards zero. On looking at the platinum plates in the water, bubbles are seen to be formed upon their surfaces, which rise in two streams to the top of the liquid; these consist of the constituent gases of the water, hydrogen being set free at the plate where the current leaves the voltameter cell—or the *cathode*, as Faraday calls it—and oxygen at the plate where the current enters, or the *anode*; some of these gas bubbles, however, are seen to cling to the plates instead of rising up through the water. On looking more closely, it is seen that the streams of rising bubbles are decreasing simultaneously with the falling off of the galvanometer deflection, and after a time this deflection settles down to a fairly constant value, which may be considerably less than that at which it started. This is an example of *polarization*; the falling off of the current has been found to be due to an opposing electro-motive force which arises owing to the deposit of a layer of oxygen on one of the platinum plates, and a layer of hydrogen on the other, which layers extend into the substance of the platinum as well as over the outer face. The tendency which these liberated gases have to combine again to form water gives rise to the opposing electro-motive force which acts against that driving the current through the cell, and the final current produced is due to the resultant of these two opposite electro-motive forces. If the two platinum plates which have thus been exposed to a current for a time be taken out of the cell and placed opposite each other in a similar trough of acidulated water, and then joined by a wire through a galvanometer, it will be observed that they now send a current themselves, but in an *opposite* direction to that which passed between them originally from the external source. They act as a battery which becomes weaker and weaker until the layers of gas sticking to their faces disappear, the oxygen and hydrogen having united again to form water. Sir William Grove discovered that if two plates of platinum were fixed, one in a closed vessel of oxygen, and the other in one containing hydrogen—the gases being obtained from any source—a current passed between the two plates when they were joined through a conductor; they behaved like the plates treated as above, and constituted a "gas battery." Such an arrangement as that described, consisting of platinum plates previously prepared by having a current passed between them whilst they dip in water, is an example of one of the earliest forms of secondary battery.

Such an arrangement, however, cannot be applied to any practical purpose, the duration of the second reversed current being quite transitory. Gaston Planté was the first experimenter to make secondary batteries on a large scale. He found lead to be the most suitable metal to use for this purpose. When two plates of lead are immersed in dilute sulphuric acid, and a current made to pass between them, one plate becomes oxidized, rusted so to speak, owing to the combination with it of the oxygen set free from the water containing the acid. Now when the current is sent in the opposite direction through the decomposing solution, entering at the plate where it formerly left, the plate which was previously oxidized becomes deprived of its oxygen, and the other plate is oxidized instead. Planté made use of this process to "form" the plates to be afterwards used in his secondary batteries; currents were sent first in one direction and then in the other through the plates and dilute acid. In course of time one of the plates, that which last formed the cathode, or the plate where the current left the liquid, became, through repeated gain and loss of oxygen, of porous structure, exposing a large surface to the solution, whilst the other became very strongly oxidized, and covered to a considerable depth with lead peroxide. When these two plates thus prepared are placed in dilute sulphuric acid, and joined by a wire, a current of Electricity passes along the wire in the opposite direction to that which was last sent through the preparing plates from an external source. This apparatus now forms a secondary battery or accumulator, which is capable of furnishing a continuous flow of Electricity for prolonged periods. The name "accumulator" is applied to such a battery from its accumulating, as it were, the chemical energy stored up in it when the charging current was passed, and afterwards giving it out in the form of electric energy. The battery thus laboriously made by Planté, which takes months to form by repeated current reversals, does not differ in any important particular from those in use at the present day, but now they are made in a much shorter time, by starting with lead oxide (or red lead) already made for one plate, instead of making this by a long-continued series of alternately reversed currents, as in Planté's original process. The plates made by the Electric Power Storage Company consist of gridiron-like arrangements, with the gaps of the framework, which is of lead, filled up with little blocks of minium or red lead. This has the advantage of offering a large surface to the action of the liquid. Formerly both of the plates of each cell had the plugs which filled up the

interstices of the grid made of a paste of red lead (Pb_3O_4), but since then litharge (Pb O), a lower oxide, has been used for those of the negative plate, and the red lead put only in that plate which was intended to be used afterwards as the positive pole of the battery. Moreover, in recent methods the two plates are "formed" apart, each by itself, and the time the current is sent through the negative plate is much longer than that applied to the positive.

The old form of secondary battery, that used by Planté and consisting of two opposed plates, one made of spongy metallic lead and the other of lead oxide, may be taken as the typical form of secondary battery, and the essential process which goes on is the transference of oxygen from the oxide of lead plate to the one consisting of metallic lead. Lead sulphate is formed as well as the peroxide of lead, and a considerable portion of the acid in the cell is used up in producing this. The current owes its origin to the presence of two substances, lead and oxygen, which have a chemical affinity for each other, and thus the action does not differ in its nature from that of an ordinary galvanic cell.

Secondary batteries require periodical renewal, as during their action the coating of lead peroxide becomes deoxidized, and both plates approach to the same composition. This re-forming is readily done by sending for some hours a current from some exterior source, such as a dynamo machine, into the cells in a direction the reverse of that of the current which is produced by the battery itself. After this the battery is restored to its original state, and is capable of furnishing a remarkably steady and unvarying current for many hours in succession.

Accumulators are a valuable source of Electricity where a considerable current is needed for lighting purposes, and are also useful as an alternative source where the dynamo is used, as, in the case of a temporary break-down of the dynamo, the secondary batteries can be switched on to the circuit. For such purposes as the electric propulsion of small vessels at sea, they seem to be the most economical means, and are beginning to be extensively used for the propulsion of electric launches and tramway cars; the secondary batteries being used to furnish the current necessary to drive the electric motor.

Dr. Frankland lit up his house years ago with success by means of secondary batteries, and when he was absent for some months and the light not used, he found on his return the batteries still in good condition, and the light ready to be turned on at once.

A DOUBLE PLANET.

By J. E. Gore, F.R.A.S.

Double stars are numerous in the heavens, and double nebulæ are not uncommon. Even double comets have been recorded, as in the case of Biela's comet, and the faint companions which have been observed in close attendance upon some of the large comets of recent years. The duplicity of one of the satellites of Jupiter has even been "suspected," but, as far as I know, the suspicion has not been confirmed. Although many of the planets of the Solar System are attended by satellites, they are usually considered as single bodies. We may however, perhaps, make an exception of this rule in the case of the Earth and Moon, which have been termed "a double planet" for the following reasons:—

The Moon's volume compared with that of its primary is greater than that of any other satellite of the Solar System. The volume is about $\frac{1}{49}$ of the Earth's volume. and its mass about $\frac{1}{81}$ of that of the Earth. The volumes of the satellites of the other planets bear a much smaller ratio to the volume of the primary. We need not consider the satellites of Mars, which are very minute bodies, and quite insignificant in size compared with their primary. The largest of the satellites of Jupiter has a volume only $\frac{1}{16000}$ of that of the "giant planet." The largest of Saturn's satellites, Titan, has probably not more than $\frac{1}{10000}$ of the volume of Saturn. The exact size of the satellites of Uranus is unknown, but judging from their faintness, we may conclude that their volume is small compared with that of their primary. Even the satellite of Neptune, supposed to be the largest satellite of the Solar System, is probably small compared with the planet. Taking its diameter at 4000 miles, and that of Neptune at 36,000 miles, the volume of the satellite will be only $\frac{1}{729}$ of Neptune's volume.

We see, therefore, that the Moon is *comparatively* a very large satellite. It is, of course, *absolutely* smaller than the largest satellite of Jupiter, Saturn's satellite, Titan, or the satellite of Neptune; but compared with the Earth, which is a small planet (in comparison with Jupiter, Saturn, Uranus or Neptune), it must be considered as really an enormous satellite, and in *relative* size deserving to rank rather as a small planet accompanying the Earth in its annual journey round the Sun, than as a satellite revolving round it.

Seen from Venus, the Earth and Moon will appear more like a "double planet" than a planet with an attendant satellite. From a consideration of the brightness of Venus as seen from the Earth, we may form an estimate of the probable brightness of the Earth and Moon as viewed from Venus. To do this it will, of course, be necessary to make some assumptions. We should require, in the first place, to know the "albedo," or reflecting power, of the Earth's surface.

To determine this accurately would not be an easy matter, but if we assume that it has the same "albedo" as the Moon, we may not, perhaps, be very far from the truth. Now Zöllner found the "albedo" of Venus to be represented by the fraction 0·50, or about three times the Moon's "albedo" (0·1736).

Venus, when at her greatest brilliancy, and approaching inferior conjunction. is distant from the Earth about 39 millions of miles, and has then about one-fourth of the area of her disc illuminated by sunlight. The Earth when in "opposition," and therefore at its brightest as seen from Venus, is distant from the planet about 26 millions of miles. Hence we have the relative distances in the ratio of 39 to 26 or as 3 to 2.

If, to simplify the calculation, we assume the diameter of the Earth and Venus as equal, the apparent areas of their discs will be as 3^2 to 2^2 or as 9 to 4. That is, the area of the Earth's disc when in "opposition," as seen from Venus, will be about $2\frac{1}{4}$ times the area of Venus's disc when at her brightest as seen from the Earth. Now as the Earth shows a *full* face to Venus when at its brightest, and Venus only one-fourth of a fully illuminated disc when at its brightest to us, we should have the Earth brighter than Venus in the proportion of 36 to 4, or as 9 to 1, *if* the distances of both planets from the Sun and their "albedos" were the same. But as their distances from the Sun are in the ratio of 93 to 67, Venus will be more brilliantly illuminated in the ratio of 93^2 to 67^2, or about as 19 to 10, and as its "albedo," as assumed above, is three times greater, we have the brightness of Venus's surface greater than that of the Earth's surface in the ratio of 57 to 10. Hence, finally, we have the

brightness of the Earth, when in "opposition," as seen from Venus, brighter than Venus at its greatest brilliancy as seen from the Earth in the ratio of 90 to 57.

Taking the diameters of the Earth and Moon as 7912 miles and 2163 miles respectively, the areas of their apparent discs would be in the ratio of 13·38 to 1. Hence, with the same "albedo," the Earth and Moon, as seen from Venus, would differ in brightness by 2·81 stellar magnitudes.

Now Plummer found that Venus at its greatest brilliancy is nine times brighter than Sirius. The Earth, therefore, as seen from Venus, would appear $(\frac{90 \times 9}{57})$ 14·21 times or 2·88 stellar magnitudes brighter than Sirius. The Earth and Moon would therefore shine as two stars, one about half as bright again as Venus at her brightest, and the other about equal to Sirius, and separated, when the Moon is in "quadrature," by about 31 minutes of arc, forming a superb "naked eye double star," perhaps the finest sight in the planetary system. They would present the appearance of a "double planet," in striking contrast with the faintness of the other satellites of the Solar System. The Earth would show a disc of about 62″ in diameter, and the Moon one of about 17″, and the markings on both might be well seen with a good telescope.

Seen from Mars, the Moon would also be visible as a small attendant planet to the Earth, but varying considerably in brilliancy owing to its phases.

The Moon's title to rank as a planet rather than a satellite is strengthened by the fact that her path in space is, like the planetary orbits, always concave to the Sun. Professor Young says in his "General Astronomy" that "if we represent the orbit of the Earth by a circle of 100 inches radius, the Moon would only move out and in a quarter of an inch, crossing the circumference 25 times in going once round it." This is a very different arrangement from the satellites of Jupiter and Saturn, which seem to form miniatures of the Solar System.

HYDROID ZOOPHYTES.

By HERBERT INGALL.

FORMERLY the study of Zoophytes could only be carried on at the sea-shore, but now continued observations of many of the lower forms of marine life can be made when far away from the sea by means of a marine aquarium at home: a better knowledge of the conditions under which sea-water can be kept renders it possible to store up subjects for study for many months, or indeed years, at a distance from the coast.

Among the smaller objects of marine life the Hydroid Zoophytes will always claim attention, not only from the beauty of their form but from the interesting and extraordinary changes they undergo during their life-history.

Who has not observed the delicate feathery masses thrown up on the beach after a storm or heavy ground swell—masses often of considerable size, but of an exceedingly fine horny substance—or noticed, when examining some clear weed-fringed pool among the rocks on a bright day, delicately curved white plumes like feathers; or seen among the tufts of weed a fine, brown, wiry-looking branching stem, the tips of the branches terminating with a sort of pink flower, which latter if watched will at intervals be seen to bend and nod? These are some of the Hydroid Zoophytes, which formerly were supposed to be a sort of link between animals and vegetables, but they now are without hesitation placed in the animal kingdom.

Three facts will be noticed in the general plan of growth of the Hydroids. There is first the general and common flesh of the composite animal called the *cœnosarc*, which may be in the form of a creeping thread, naked, or covered with a *chitinous* or horny substance, which latter is almost always present in the arborescent or branching forms and serves to support them; or the *cœnosarc* may be present merely in the form of a thin filament connecting the separate polyps, but in any case it answers the same purpose, which is the general connection of the whole mass of polyps forming the individual colony, and the circulation and conveyance of nutriment over the whole. Secondly, the *polypites* or flower-like animals, that develop at the ends of the branches in the arborescent forms, or may bud out at any part in those that have the *cœnosarc* adherent to stones or shells: these serve to collect and catch food, and even living prey, by means of thread-like arms or tentacles. And, thirdly, the reproductive or sexual buds, called the *gonophores*, in which are developed the elements for the propagation of a new colony: the object so produced is called the *gonozooid*.

I have had under observation for many months a colony of *Podocoryne carnea*: they were obtained at Hastings last September. In passing through the old town I noticed some fresh specimens of Dog Whelk (*Nassa reticulata*) lying in the roadway, and, seeing that they had evidently not long come from the sea (no doubt having been just thrown out of some fishing boat), I placed them in my collecting jar, from which they were transferred the same day to an aquarium at home.

A curious association exists between many of the lower animals quite dissimilar in structure—the connection of Podocoryne with the Dog Whelk (*Nassa*) is almost constant, and the obvious explanation would seem to be that the rough shell and the roving life of this whelk is favourable for the development of the polyps; the scavenging and carnivorous habits of the Dog Whelk must be the means of a much more constant supply of food to the lower animal than it could obtain alone. The presence of an allied form (*Hydractinia*) on shells inhabited by the Hermit Crab, may also be ascribed to similar causes, but it is somewhat singular that they should each keep to their own host; we seldom find Hydractinia on Nassa, or Podocoryne on Pagurus, at least so far as the writer's experience extends.

The Polyps composing the colony form an elegant covering to the somewhat sombre-coloured shell of the mollusc over which they wave about like a delicate feathery veil, the beauty of which is enhanced by the lively habits of the Dog Whelk.

The *Polypites* are of a delicate white colour (presenting the appearance shown in Fig. 1). They are furnished with an opening at the upper end, and eight delicate arms, or tentacles, situated a little below and around the mouth; these serve to arrest any small particle of food or minute animals, and to bring them to the mouth, but it is very probable that many or all of these lower animals are not altogether dependent on the solid food caught by the tentacles; extremely minute organisms are always present in the sea, and they are most likely absorbed by the walls of the digestive cavity. The body of Podocoryne is very extensile (as are also the tentacles), and it is attached at its lower end to the *cœnosarc*, a delicate creeping covering of fleshy matter which, in this case, closely follows the indentations and reticulations of the shell, quite avoiding the elevated parts or bosses,

FIG. 1.

which protect the animal from getting rubbed off, as it otherwise would, owing to the violent movements given to the shell at times. By the gradual growth of the *cœnosarc*, and the budding up at intervals, the colony spreads over the shell. Besides the *polypites* there spring at times, more often on the rim of the shell, other curious processes, which although they appear to be of somewhat the same substance as the polyps, never attain their form. They are like *thin curved filaments* and roll and unroll in a most curious and lively fashion; they are probably accessories to nutrition, and act as fishing lines.

The colony may go on increasing in this manner for some time, till it almost covers the object on which it grows; after a time, however, according to conditions (generally in the summer or autumn), many of the *polypites* begin to show little buds just below the tentacles. They appear as an enlargement of the *ectoderm* or outer body of the polyp. (Fig. 2). These are the *gonophores* which develop the motile form or *gonozooid*, whose office is to found a future independent colony. This bud gradually enlarges, till the ectotheca or external covering bursts, and the *gonozooid* or *medusa* form (still attached to the polypites by a narrow stem) unfolds itself. (Fig. 3.) An hour or so of pulsations or contractions of the bell, and the new body breaks from the stem of the parent, and dances away through the water, a lovely translucent bell, the minute structure of which will be better seen in Fig. 4. Here we have a delicate transparent bell, somewhat contracted at the opening, where the rim is bounded by a sort of circular canal. From this at regular intervals proceed eight arms or tentacles, very similar in structure to the tentacles of the polypite, being very contractile and furnished with *nematocysts* or thread cells, which are supposed to have a deadly poisonous and paralyzing action on any living thing touched by them; but this I think is scarcely proved, as the irritating effects, well-known to bathers, in the case of the larger medusæ, may be caused by the mechanical effects of the number of minute threads shot out into the surface nerves of the skin. It has also been constantly observed that small entermostracæ, after being caught and held some time by the tentacula, get free and swim away apparently none the worse. At the base or root of each tentacle will be observed a semi-opaque granular mass; this is called the *ocellus*, and is supposed to be an organ of sense. From the apex, and hanging down into the cavity of the bell (which we may here also observe is partially closed at the bottom by a delicate horizontal membrane called the *vellum*) is a kind of "clapper," which is really the body of the gonozooid, and is called the *manubrium*, at the tip of which is the mouth, furnished with four short fringed lips, which are very sensitive, and constantly in motion. In the walls at the side of the manubrium are developed the ova and spermatozoa for the founding of a new colony of polyps,

Fig. 2.

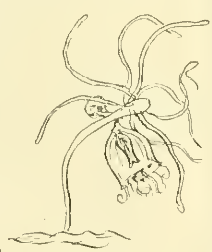


Fig. 3.

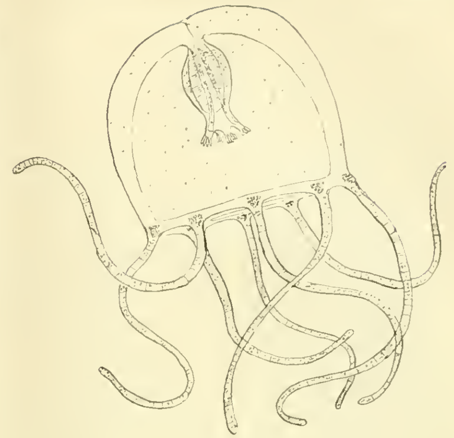


Fig. 4.

and the life-history of the animal is complete. This may be considered as a type of the ordinary history of the *Hydroids*. In general the polypite colony is the permanent form, and the medusoid state the ephemeral one; indeed, one may compare the medusa form of the polyp to the butterfly or the winged aphide, or to the flower on the plant. To quote Van Beneden: "Dans les plantes comme dans les animaux la vie est generalement longue et la tenacité grande dans les individus agames, éphémére et delicate, au contraire, dans les individus sexués. L'ánalogie entre la meduse et la fleur se confirme de plus en plus."

I have taken this particular zoophyte as an illustration of others because it can be easily procured and kept in the aquarium, but the student who wants to see this marvellous life-history of the Hydroids will find abundant variety of other forms. In some of them the gonozooid is of more complex and larger form, but on this occasion I have only described what I have actually seen myself.

THE FACE OF THE SKY FOR SEPTEMBER.

By Herbert Sadler, F.R.A.S.

GROUPS and isolated sunspots are increasing in size and frequency. The following are conveniently observable minima of someA lgol type variables (*cf.* "Face of the Sky" for July): Algol.—September 3rd, 6h. 24m. p.m.; September 20th, 11h. 17m. p.m.; September 23rd, 8h. 6m. p.m. U Coronæ.—September 4th, 10h. 31m. p.m.; September 11th, 8h. 14m. p.m. U Ophiuchi. — September 1st, 7h. 49m. p.m.; September 6th, 8h. 36m. p.m.; September 11th. 9h. 21m. p.m.; September 16th, 10h. 7m. p.m.; September 21st, 10h. 52m. p.m.; September 27th, 7h. 16m. p.m.

Only two planets can be really conveniently observed in September, Venus being in superior conjunction with the Sun on the 18th; Mars, though rising on the last day of the month two hours before the Sun, has too small a diameter (4·0″) to be of any interest to the amateur; Saturn is in conjunction with the Sun on the 13th; and Uranus and Neptune are too near the Sun, as evening and morning stars respectively, to be observed with any profit.

Mercury, though in inferior conjunction with the Sun on the 13th, and therefore invisible during the first half of the month, becomes a striking object in the morning sky during the latter part of September. On the 19th he rises at 4h. 42m. A.M., or 1h. 1m. before the Sun, with a northern declination of 4° 37′, and an apparent diameter of $9\frac{1}{2}''$, about $\frac{1}{10}$ of the disc being illuminated. On the 24th he rises at 4h. 17m. A.M., or about 1h. 33m. before the Sun, with a northern declination of 6° 17′ and an apparent diameter of about 8″, about $\frac{3}{10}$ of the disc being then illuminated. On the 29th he rises at 4h. 13m. A.M., or 1h. 45m. before the Sun, with a northern declination of 5° 33′, and an apparent diameter of $6\frac{3}{4}''$, about $\frac{54}{100}$ of the disc being then illuminated. He is at his greatest western elongation (17° 51′) on the 28th, and during the last three or four days of the month presents pretty configurations with Mars, Saturn, and the Moon (on the last day). While visible he describes a short looped path on the confines of Leo and Virgo, but without approaching any very bright star.

Jupiter is now a magnificent object in the evening sky, being visible all night long. He is in opposition to the Sun on the 5th, being then at a distance of about 369 millions of miles from the earth. He rises on the 1st at 6h. 56m. P.M., with a southern declination of 7° 50′ and an apparent equatorial diameter of 49·2″, and on the 30th at 4h. 54m. P.M., with a southern declination of 9° 12′, and an apparent equatorial diameter of 48·2″. The following phenomena of the satellites occur before midnight, while Jupiter is more than 8° above and the Sun 8° below the horizon. On the 1st a transit egress of the shadow of the second satellite at 8h. 20m. P.M., and a transit egress of the satellite itself at 8h. 31m. P.M. On the 3rd a transit egress of the shadow of the fourth satellite at 10h. 19m. P.M., and of the satellite itself at 10h. 33m. P.M. Before midnight on the 5th all the satellites will be to the west of the planet. On the 6th a transit ingress of the first satellite at 11h. 9m. P.M., and of its shadow one minute later. This transit should be carefully watched, as the satellite will probably be seen projected on its shadow. On the 7th an occultation disappearance of the first satellite at 8h. 24m. P.M., and an eclipse reappearance of the first satellite at 10h. 43m. 25s. P.M. On the 8th a transit egress of the first satellite at 7h. 53m. P.M., and of its shadow five minutes later; a transit ingress of the second satellite at 7h. 57m. P.M., and of its shadow eight minutes later; and a transit egress of the second satellite at 10h. 48m. P.M., and of its shadow ten minutes later. On the 10th a transit ingress of the third satellite at 7h. 31m. P.M., and of its shadow at 7h. 59m. P.M.; a transit egress of the satellite at 10h. 51m. P.M., and of its shadow at 11h. 25m. P.M. On the 14th an occultation disappearance of the first satellite at 10h. 8m. P.M. On the 15th a transit ingress of the first satellite at 7h. 18m. P.M., and of its shadow at 7h. 34m. P.M.; the egress from transit of the satellite at 9h. 36m. P.M., and of its shadow at 9h. 52m. P.M.; a transit ingress of the second satellite at 10h. 13m. P.M., and of its shadow at 10h. 43m. P.M. On the 16th an eclipse reappearance of the first satellite at 7h. 7m. 22s. P.M. On the 17th an eclipse reappearance of the second satellite at 7h. 56m. 20s. P.M.; a transit ingress of the third satellite at 10h. 46m. P.M., and of its shadow at midnight. On the 21st an occultation disappearance of the first satellite at 11h. 53m. On the 22nd a transit ingress of the first satellite at 9h. 2m. P.M., and of its shadow at 9h. 28m. P.M.; a transit egress of the satellite at 11h. 20m. P.M., and of its shadow at 11h. 47m. P.M. On the 23rd an eclipse reappearance of the first satellite at 9h. 2m. 37s. On the 24th an occultation disappearance of the first satellite at 6h. 45m. P.M., and its reappearance from eclipse at 10h. 31m. 51s. On the 26th all the satellites will be to the west of the planet. On the 28th an eclipse disappearance of the fourth satellite at 8h. 6m. 53s., and reappearance at 11h. 48m. 19s.; an eclipse reappearance of the third satellite at 9h. 20m. 7s. On the 29th a transit ingress of the first satellite at 10h. 47m. P.M., and of its shadow at 11h. 23m. P.M. On the 30th an eclipse reappearance of the first satellite at 10h. 57m. 57s.

There are no well-marked showers of shooting stars in September.

The Moon is new at 8h. 16m. A.M. on the 2nd; enters her first quarter at 11h. 7m. A.M. on the 11th; is full (Harvest Moon) at 5h. 4m. A.M. on the 18th; and enters her last quarter at 11h. 7m. P.M. on the 24th. She is in apogee at 8·2h. P.M. on the 4th (distance from the earth 252,610 miles), and in perigee at 6·4h. A.M. on the 18th (distance from the earth, 221,720 miles). Her greatest eastern libration is at 5h. 15m. A.M. on the 12th, and her greatest western at 8h. 5m. A.M. on the 24th.

This is a very remarkable Harvest Moon, as the Moon attains her perigee less than an hour and a half after she is full, and her approach to the earth is one of the closest possible, the minimum distance at perigee being, according to Neison, 221,614 miles.

Chess Column.

By C. D. Locock, B.A.Oxon.

To Correspondents.—Communications for this column should be addressed "C. D. Locock, *Cintra, Hawkhurst, Kent,*" and posted *before* the 10th of each month.

Solution of Problem No. 2 (*by G. F.*): 1. Q to KKt2 :—

1. . . R to KKt8 (or Kt checks)	2. K to B7, etc.
1. . . Kt × Kt	2. Q to Kt3 ch, etc.
1. . . R to Q R 4	2. Kt to K4 ch, etc.

The words "White" and "Black" were accidentally transposed on the diagram. Fortunately the mistake was one which, if noticed, should easily be suspected.

Correct Solutions from :—Alpha, K, M. B. (Jesmond), C. S., W. T. Hurley, R. W. Houghton, E. B., C. T. Blanshard, Giu. Pianissimo, T. A. Earl, T. E. Kerrigan, W. E. B., F. R., J. Landau, R. T. M., A. Rutherford, T., J. Taylor—(18 correct; 4 partly incorrect).

Alpha. — First again, according to your prerogative. Your criticisms are just. No. 2 is, the composer tells us, his third attempt only.

Betula.— You are wrong in giving *two* continuations for White after 1. . . R to R4, and again after 1. . . Kt × Kt, *e.g.*, 1. . . R to R4; 2. K to B7 (?), R to KB8; 3. No mate. Or 1. . . Kt × Kt; 2. K to B7 (?), Kt to K5; 3. No mate. Hence the deduction of four points. Your problem, though simple, is neat and artistic. With ties in prospect, it may be necessary to defer its insertion till after the tourney closes.

A. C. L. W.—If 1. . . Kt × Kt; K to B7, Kt to K5; 3. No mate. This loses two points.

G. F.—Omitting R at QR8 does away with variation 3. Omitting the other Rook permits a dual in the same variation. The White Pawn at KR3 instead of Black Pawn at KR7 would be an improvement. Thanks for the game, for which room may be found soon. Glad you like the articles.

C. S.—Could you not find another first move? A determination to do so might lead to other improvements in construction.

H. W. P.—Solution of problem No. 1 posted July 23, and cannot therefore count in the competition, being a fortnight beyond the limit.

J. Johnston and *T. H. Billington* (Wolverhampton).—See first part of answer to "Betula." By a curious coincidence you both give in two variations 2. Q to B3 ch. (obviously a misprint for Q to Kt3 ch.). No deduction has been made for this.

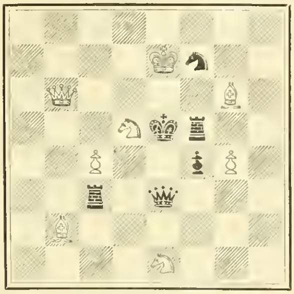
T. H. B.—Thanks for problem, which shall be examined.

J. J.—With the exception of the key-move, your solution is totally incomprehensible. In some of your variations the White Pawns move in the same direction as the Black.

PROBLEM (No. 3).

By C. D. L.

Black.



White.

White to play, and mate in two moves.

Solvers' Scores.

Alpha	11	J. Taylor	11
W. E. B.	11	A. C. L. Wilkinson	9
T. E. Kerrigan	11	T. H. Billington	9
W. T. Hurley	11	Betula	7
K.	11	J. Johnston	3
Giu. Pianissimo	11	A. G. Hansard	3
T. A. Earl	11	T. K. Bentley	3
F. R.	11	F. W. Sharp	3
R. W. Houghton	11	White Knight	3
G. F.	11	A. J. Luisham	3
E. B.	11	J. Humble	3
C. S.	11	A. N. Brayshaw	3
M. B. (Jesmond)	11	R. A. Layton	3
C. T. Blanshard	11	J. G. Ellis	3
R. T. M.	11	H. C. H.	3
J. Landau	11	H. S. B.	0
A. Rutherford	11	F. de F.	0
T.	11		

Scores under 6 will be omitted in uture.

CHESS INTELLIGENCE.

The Counties Chess Association held its meeting at Oxford during the first week in August. In the principal tournament a tie resulted between Mr. J. H. Blake, of Southampton, and the Rev. A. B. Skipworth, the Hon. Sec. of the Association. Their scores were the high ones of 7½ out of a possible 9. Other scores were necessarily low, the Rev. J. Owen and Messrs. Trenchard, Lambert and Jones-Bateman being equal with 4½. Mr. Thorold was half a point behind. The tie for first prize and possession of the challenge cup will be played off in London, probably in October. Mr. Blake having been successful "in the personal encounter" (to use Mr. Steinitz's expression) will be perhaps slightly the favourite.

Game played in the Divan Tournament:—

French Defence.

White. (R. Loman.)	Black. (N. Jasnagrodsky.)
1. P to K4	1. P to K3
2. P to Q4	2. P to Q4
3. QKt to B3	3. KKt to B3
4. P to K5	4. KKt to Q2
5. P to B4	5. P to QB4
6. P×P	6. Kt to QB3 ! (*a*)
7. Kt to B3 (*b*)	7. Kt×P ? (*c*)
8. B to Kt5	8. B to Q2
9. Castles	9. P to QR3 (*d*)
10. B×Kt	10. P×B
11. K to Rsq (*e*)	11. B to K2
12. Kt to Q4	12. Kt to Kt2 (*f*)
13. Q to Kt4	13. P to Kt3
14. B to Q2	14. P to QB4
15. KKt to K2 (*g*)	15. Kt to R4
16. QR to Ksq	16. R to QKtsq
17. B to Bsq	17. Kt to B3
18. Q to R3 (*h*)	18. Kt to Kt5
19. P to QR3	19. Kt×P
20. R to Qsq	20. Kt to R8
21. P to B5 !	21. Kt to Kt6 (*i*)
22. P×P	22. BP×P
23. B to R6	23. B to R5 (*j*)
24. R to B3 (*k*)	24. R to Ktsq (*l*)
25. QR to KBsq	25. B to K2
26. Q to Kt4	26. Kt to Q5
27. Kt×Kt	27. P×Kt
28. Q×QP (*m*)	28. Q to Kt3
29. Q to KB4	29. B to B3 (*n*)
30. B to B8 !	30. R×B
31. Q×Rch	31. K to Q2
32. Q to B4 (*o*)	32. P to QR4 ? (*p*)
33. Kt to R4	33. Q to Kt4
34. P to QKt3	34. Q to K7 (*q*)
35. Q to Q4	35. R×P
36. Q to R7ch	36. R to Kt2 (*r*)
37. Kt to B5ch	37. B×Kt

Position after Black's 37th move.

Black.

White.

White mates in six moves by

38. R to B7ch	38. B to K2
39. R×Bch ! (*s*)	39. K×R (*t*)

40. Q to B5ch, and mates in three more moves.

NOTES.

(*a*) Much better than either 6. . . . B × P; 7. Q to Kt4, or 6. . . . Kt × P; 7. B to K3, or 7. Kt to B3. Delaying the capture puts White in a dilemma, for he cannot tell how the Pawn will be taken.

(*b*) If 7. Q to Kt4 ?, Kt × BP; 8. B to K3, P to Q5; 9. Castles, Q to Kt3! winning the exchange. 7. P to QR3 is sometimes played, and has the merit of compelling Black to show his hand (otherwise White will defend the Pawn by P to QKt4), but does not in other respects aid development. We would suggest 7. B to K3, as the safest continuation, but disbelieve in the whole attack. Mr. Loman's move is of doubtful value, shutting out, as it does, the Q from Kt4.

(*c*) For Black could now hamper development considerably by B × P. White now hastens to Castle while he can.

(*d*) A lost move; the Bishop is quite harmless. He should play either 9. . . . B to K2, or 9. . . . Q to Kt3; for if then 10. B to K3, Kt × P!; 11. Kt × Kt, B × B; 12. P to QKt4, B × R; and though White gets some attack by retaking the Bishop at once, it should be parried by careful play.

(*e*) Kt to Q4 might be played at once.

(*f*) Castling is much better. If then 13. Q to Kt4, P to KB4, followed by Kt to K5, and P to QB4 if the Queen moves.

(*g*) Perhaps Kt to B3 is preferable, leaving K2 for the other Knight.

(*h*) The key-move of an ingenious plan for breaking through on the King's side.

(*i*) If KtP × P, 22. B to R6, Kt to Kt6; 23. B to Kt7 wins.

(*j*) The only move. If 23. . . . R to Ktsq, 24. Q to B3, B to QBsq.; 25. Q to B7ch, and 26 Kt × P.

(*k*) Or 24. Q to B3, Q to K2; 25. P to Kt3 (not 25. R × P ?, P × R; 26. Kt × P, B to B3 !).

(*l*) To prevent B to Kt7 after the next move on each side. The best defence, however, is probably B to Bsq.

(*m*) If 28. Q to B4, B to Kt4 ! Not 28. . . . QB to Bsq; 29. Q to B7ch, K to Q2; 30. Kt × P, &c.

(*n*) Overlooking White's brilliant reply. K to Qsq. was the only move.

(*o*) Best. If Q to Kt7 Black can safely take the KtP.

(*p*) Not to much purpose, Probably his best chance of drawing lay in R to KBsq., in order to remain with two Bishops against a Rook and Knight.

(*q*) Baiting a trap to catch himself.

(*r*) If K to Ksq. White forces the game by 37. R to B8ch, B × R; 38. Q to B7th, 39. Q × Bch, and 40. Q to Q6ch, mating in a few moves, or winning the Queen. The variations are worth following out.

(*s*) A very brilliant termination.

(*t*) If K to Qsq mate follows in three moves by R to B8ch, etc.

KNIGHTS AND BISHOPS.

(*Continued from p.* 160.)

4. A Bishop acts *at a distance*. This power is of great importance in attacking the adverse King. To take a simple instance: A Bishop checks a King; the King can never move so as to gain time by attacking the Bishop in turn. On the other hand, when checked by a Knight the King has *two* squares available for coming in contact with the attacking piece. Take again the case where a Knight is used to defend a single Pawn in the end-game. The adverse King (or Queen) by attacking both at once wins one or the other. A Bishop in a similar situation would simply move away, still holding on to the Pawn. Hence we get the corollary that in *defending* Pawns a Bishop is superior to a Knight; in *attacking* them the case is reversed (*vide* point 2).

5. Again, in the end-game a Knight is inferior to a Bishop in the art of *stopping* passed Pawns. Imagine a diagonal series of six Pawns extending from Black's QKt2 to his KKt7. A White Bishop, by simply occupying the diagonal in front, effectually stops the whole six from advancing. A Knight would be helpless against more than *two* of the six. In the case of a single adverse passed Pawn advancing to Queen, it is obvious that, while a distant Knight will have to start at once in order to catch it, a Bishop may quietly wait until the Pawn has reached the sixth or seventh row. This is owing to the superior *pace* of the Bishop.

6. A Bishop can *gain a move*, *i.e.*, it can take, if necessary, an *odd* number of moves to leave and regain the square which it occupies. This is sometimes of importance in the end-game, and here again the Knight is at a disadvantage, the process mentioned invariably taking an *even* number of moves.

7. A Bishop can *confine* a Knight at the side of the board. This, of course, will seldom occur except in the end-game.

8. A Bishop "pins"; a Knight "forks." The latter is, we think, by far the more dangerous gift. There are more opportunities for its exercise, and there is no "interposing" against a "fork." The summing-up and verdict must be deferred till the next number.

CONTENTS OF No. 70.

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CONTENTS.

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EARWIGS.—I.

By E. A. Butler.

The family of British Earwigs is a small one, numbering at present six species; no more than two of these, however, are common, and probably most people know only one, which to them therefore ranks as *the* Earwig. This is the insect whose scientific name is *Forficula auricularia*, the well-known species which is to be found abundantly everywhere. We will take this common and easily obtained insect as the type of the group, in the hope that our readers will catch one, and follow with us the outline of its form; the deviations of structure which the other species present will then be easily appreciated. The common Earwig is so well known that only a few words will be necessary to add accuracy of detail to the rough general idea of its shape and structure that is already in everybody's mind. Exclusive of the forceps at the end of the body, which vary considerably in size, the common Earwig has a length of about half an inch. It has a flat, rounded, reddish head, carrying a pair of 15-jointed antennæ, at the base of which, but outside them, are the black, oval, compound eyes, which lie flat and do not project from the head. No ocelli, or simple eyes, are present.

Behind the head is the thin, flattish, shield-like cover of the first segment of the thorax, which projects at the sides as a kind of flap, and behind laps over the front of the wing-covers. It is dark brownish-black in the centre, with pale yellowish borders. Behind this is a pair of pale yellowish-brown wing-covers, or elytra, which are thin and flexible, and lie flat on the back, but bend down at the sides like those of the house-cricket; when closed they exactly meet, with a straight junction along the middle line. Their hinder edge in reality forms almost a straight line across the body, but at first sight this does not seem to be the case; they appear to have two projecting pieces in the middle of this edge, which remind one of the shape of the two halves of the cloven hoof of a cow, save that they are almost flat. These, however, are not part of the wing-covers at all, as may easily be proved by raising the latter with the point of a needle, when these projections are seen to be in no way attached to them; they belong in fact to the wings, which, except for this part, are entirely concealed under the covers. The wings and their covers when closed, as one usually sees them, are so short that they conceal little more than the hinder part of the thorax, and thus leave almost the whole of the abdomen exposed.

The abdomen is by far the largest part of the insect, being the longest, the widest, and the deepest, so that when the Earwig walks the fore part of the body is elevated a little on the legs, while the abdomen almost trails along upon the ground (Fig. 1). Nine distinct segments can be seen above in the abdomen of the male, but only seven in the female; they are of a mahogany-brown colour, more or less tinged in places with black. To the hindmost segment are attached the forceps, by which feature alone Earwigs

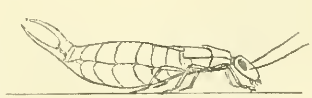


Fig. 1. Position of Earwig when walking.

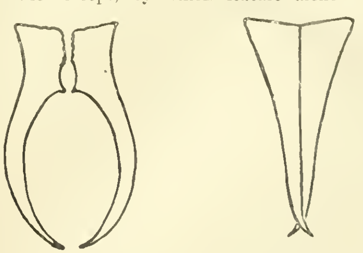


Fig. 2. Forceps of Earwigs.—A. male; B. female. Shown in the position they take up after death. Magnified six diameters.

can be distinguished from all other insects. They differ considerably in shape in the two sexes (Fig. 2); in

the male each forms a curve, so that when closed they constitute the boundaries of an open oval space. On the inner edge, near the base, they are ornamented with small, irregular, tooth-like projections, and beyond these on each side there is a solitary but much larger one, just where the "legs" of the forceps begin to diverge. The forceps are strong, stout organs, of a yellowish-brown colour, with the teeth blackish; they are highly polished, and exhibit in different specimens considerable variety as to length and degree of curvature. Sometimes, through accidents in early life, they become twisted, or otherwise deformed. Those of the female are simpler and less elegant. They do not curve outwards when closed, but lie side by side as far as the tip, where they cross one another slightly. In both sexes they are habitually carried widely open, and pointing obliquely upwards. The six legs are yellowish and almost transparent, and are composed of the usual parts.

Such is the external aspect of the common Earwig, from which we may now pass to consider the structure and manipulation of the wings, which are by far the most beautiful part of the insect, and deserve special attention. It is very seldom that the wings can be seen when the Earwig is alive, for they are used chiefly by night, and one can have no conception of their size, or of the beauty that lies concealed under their covers, if one merely watches the running insect; indeed, it is difficult under such circumstances to believe even in their existence. To examine the wings properly the Earwig must be killed; this may be done instantaneously, and without damage, by plunging it into boiling water. Let it then be placed on blotting paper to dry it, and afterwards laid full length upon some hard surface. Then let the wing-covers be raised and separated a little towards the right and left; a neat little package will thus be found under each, which, strange as it may appear, is really a beautiful transparent wing, folded up into extremely small compass. By dint of care and patience it may be opened fold after fold till its full extent is exposed, when it will be found to spread over an area some seven or eight times as large as the cover under which it was hid.

The complete unfolding of the wing is a delicate operation, and must be managed methodically. The following method will succeed very well if the directions are carefully attended to. The wing-cover having been removed by raising it behind and then gently snipping it off in front with a fine pair of scissors, the folded wing lying beneath may be carefully seized with forceps, lifted up and snipped off in the same way as the cover, or it may be gently pulled away from its attachment. As it is too small to be conveniently manipulated unless when fixed to some support, a card should be provided, on which may be placed with a small camel's-hair brush a very little gum tragacanth, made by soaking a small piece of the solid gum in water till it is of the consistency of rather thick paste. The gum will very quickly dry if only small quantities are used, and leave no trace behind; it should not be put on the card till the wing is ready to be transferred to it. The wing packet may now be placed gently on the gum with the *upper* surface *downwards*. In a few minutes the gum will be dry and the wing will thus be fixed (Fig. 3, A). By aid of a needle it will now be found that there are two layers of material folded upon one another like the leaves of a book. One of the edges will be observed to be straight, the other curved; the straight one is where the fold occurs. By aid of the needle the flap may be lifted and turned over along this hinge and pressed down on to another small supply of the gum, which may be put on just in time to receive it. The wing will now of course be twice as broad as before, and will present the appearance shown in Fig. 3, B. It will now become evident that the part that has been turned

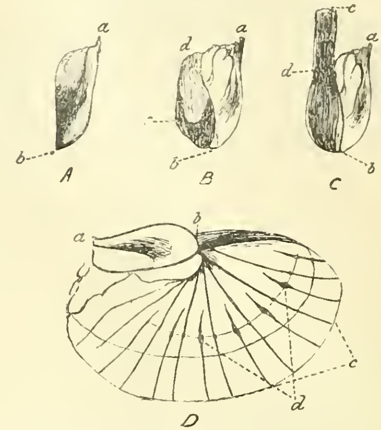


Fig. 3. Four stages in unfolding Earwig's left wing. The small letters represent the same parts in all the figures. Magnified six diameters.

back itself consists of two layers, bent upon one another not in the same direction as before, but with the hinge lying *across* the wing at its upper end. The uppermost flap may easily be bent back across its hinge, when the wing will appear as in Fig. 3, C. This last piece should not be fastened down, but simply pressed back. Now comes the most difficult part of all. The long smoky part which occupies the whole of one side of the wing as it is now displayed consists of a thin membrane strengthened by leathery rays, and arranged in a number of longitudinal folds, and the whole is bent back upon that part of the wing that is attached to the card at the end opposite to the position of the former hinge. It may be lifted at *d*, and as it is raised the membrane gradually opens itself out in all directions. The outer edge may be gently pushed back on to the card, on which another small supply of gum has just been spread, and if care be taken to keep the narrow dark triangle shown at *b* (Fig. 3, D) in the same line as the original outer boundary of the wing, the rest will fall pretty easily into its place, and become neatly spread out on the card. If it does not settle on the gum quite smoothly the wrinkles may be got rid of by using the needle as a sort of rolling pin, and rolling it out from the stouter towards the weaker margin of the wing. This last operation requires care, as the membrane is very easily torn. We now have the whole wing expanded with its under surface uppermost. It will keep any length of time in this position.

To understand why the wing always folds in precisely the same way, attention should be directed to the membranous part last exposed. From the joint *b* (Fig. 3, D) nervures will be seen radiating like the framework of a fan. About half-way down its length, each dilates into a minute swelling, and as the individual rays diverge more and more, other shorter ones are seen to spring up alternately with them, passing outwards to the edge of the wing, but not reaching the hinge aforesaid. These also have each a similar but much larger swelling, the whole set forming a row parallel to the hind margin of the wing (*d*, Fig. 3, D). The membrane having been folded like a fan

along the lines of the radiating nervures, all these little leathery spots are brought up side by side, and the whole collection is then bent across at this spot, thereby reducing the membrane to half its length. A transverse nervure running parallel to the hind margin, but nearer to the line of bending than to it, serves to give stability to the wing when fully expanded. The rays are the divisions of the anal nervure, the area of which in most insects forms only a small part of the wing nearest the body, but in the Earwig has so far expanded and encroached as to constitute almost the whole wing.

The wing readily closes of its own accord at the transverse bends, in virtue of its own elasticity; but obviously this must be overcome in opening by some external force, and it is just here that the forceps at the end of the body come in usefully. The Earwig is said to use its forceps to aid the operation, turning them over its back to do so. There is great difficulty in verifying this statement, owing to the nocturnal habits of the creature and its general disinclination to use its wings. If the wings are opened artificially, the Earwig will often go for hours without closing them, and then when it finally does so, probably the experimenter is absent. It is said also to use the forceps in closing the wings, though from the nature of things it would seem that they would be less required then. There are some foreign species whose forceps are as long as the body, and it is difficult to see how these can make such a use of their exaggerated tail appendages. The forceps are of course weapons of offence and defence as well, and are probably quite as effectual by giving a terrifying appearance to the insect as by being actually used for pinching.

The Earwig is one of those insects whose metamorphosis is incomplete, like the cockroach, cricket, and bed-bug. The eggs are little oval yellow things; they may sometimes be found under stones, &c. De Geer has left an account of a mother Earwig which he found with a batch of eggs, which implies that these insects, contrary to the general practice, show maternal solicitude. He placed the eggs in a jar, scattering them over the surface of some earth it contained, and then put the mother in. She immediately set to work picking up the eggs with her jaws, and conveyed them all to the same spot, where she remained jealously guarding her treasure till the young were hatched. And even then the cares of maternity were not over, for the young ones clustered round their mother, running in and out between her legs and under her body, like chickens under the mother hen. When first hatched, the young are quite white, except for the eyes and jaws, which are reddish. They soon darken, however, into a tolerably uniform pale brown. They are very similar in shape to the adult, but have no wings or wing-covers, while their antennæ also have fewer joints, and their forceps are more simple in form. After several moults, each accompanied by an increase in size and a darkening in colour, they appear, like the cockroaches and crickets, with the outline of wings sculptured on the thorax; in this form they are called nymphs or pupæ. The next moult yields the perfect and mature insect, with the full number of joints to the antennæ, wings, wing-covers, and forceps all perfect, and the sexual organs fully developed. At each moult the insect is soft and white immediately after casting the skin, but gradually becomes harder and darker by exposure.

Earwigs are extremely voracious; they are chiefly vegetable feeders, and are especially fond of the corollas of flowers, so that they are a great annoyance to gardeners by nibbling the flowers and thus spoiling their symmetry. Their method of procedure can be easily watched by putting a few specimens in a glass jar and supplying them with flowers such as the garden nasturtiums (tropæolums). The jaws work in the same way as those of cockroaches, the palpi being in incessant motion all the time. Earwigs can run up and down the perpendicular sides even of a glass jar with perfect ease, an accomplishment very essential to their well-being, as their favourite food so often lies up on the end of a tall stalk. Hence, one can account for their presence in sunflowers and other tall flowers, without assuming that they have flown thither. They habitually rest with legs widely spread out, and this, no doubt, helps to give them a firm foothold. On the other hand, however, as everybody knows, they are extremely ready to relax their hold and drop at once to the ground, if disturbed. They are fond of the darkness, and it would almost seem as though light were painful to their eyes, for they habitually endeavour, when disturbed in the daytime, to poke their heads into some obscure corner.

Earwigs, although they make a good deal of mess in the places they frequent, by the abundant accumulation of their excrement, are yet not in themselves of uncleanly habits, but are in person usually scrupulously clean. If watched for a little while they will be seen cleaning themselves as a cat would do, putting the forefoot up to the mouth and then rubbing it round the head; the hind foot will also sometimes be bent round underneath and brought up to the mouth in the same way, just as we described in the case of the Book-louse, and after some tremulous movements with the jaws and palpi, it will be stroked down the back several times, evidently with the intention of removing particles of dust, &c. There is a surprising air of intelligence about them as they perform their ablutions, and a steady, business-like application to the work, which is highly amusing. A similar appearance of a power of resource and vigour of purpose are often to be seen while they are feeding, especially when an Earwig, reaching up to a flower above its head and almost too high for it, gives it little tugs with a jerk of the head, like a horse pulling hay out of a rack.

(To be continued.)

INTERNATIONAL YACHTING.

By Richard Beynon, F.R.G.S.

THE ascendancy of Great Britain over the other maritime nations of the world, in the size and number of her merchant vessels and the skill of her shipbuilders, is undoubted. There is one department of our marine, however, in which the place of supremacy is very closely contested by other countries. British yachts are not allowed to retain a position of pre-eminence among the pleasure craft of the world without encountering the powerful rivalry, first of the United States, and secondly of France. In discussing the subject of International Yachting it would be well to consider first the different types of yachts obtaining in the Eastern and Western Hemispheres. It must be remembered that the law of the survival of the fittest holds good in yachting, and the kinds of boats used in English and American waters are those which are best adapted for the special conditions of water and weather they have to encounter. In the United States, yachting is chiefly prosecuted along the Atlantic seaboard, and as the prevailing winds are westerly, it follows that Americans have the shelter of their eastern coast line to shield them from high westerly winds, and to ensure them comparative calm water for their sport. In England it is very different; the south and west coasts are those most affected by yachts-

men, and these are exposed to the full force of Atlantic seas. Hence it follows that the English yacht must be a boat of greater stability than the American type, one that is able to make good weather in a rough seaway, and need not always run to port on the approach of half a gale of wind. This structural difference between British and American types is much accentuated when an international race comes off. The American type is possessed of greater stiffness than English yachts usually are, and consequently can carry greater sail spread. This stiffness holds good only through the ordinary inclinations at which yachts are sailed. At an angle when the British deep-keel boat is perfectly safe, the stability of the centre-board boat vanishes altogether. Thus the celebrated *Volunteer* could carry an enormous spread of canvas until an inclination of 76° was reached, when its stability vanished. The *Thistle*, however, now the *Meteor*, is practically uncapsizable. In ordinary weather the centre-board has the advantage of being able to carry more canvas on a more even keel than the English type of yacht, and at the same time possesses the additional advantage of making less leeway without increase of wave-making resistance. The superiority of the British yacht needs rough weather to demonstrate it. Safety is assured where the American type would be absolutely unsafe. A glance at the loss of life attendant upon British and American yachting shows the truth of this statement. Of course it is impossible that English yachting should be prosecuted with the ardour so characteristic of yachtsmen without disaster of some kind. During the three years ending June, 1887, the average loss of life from yachting accidents was ten. The season 1887-8 gives a loss of eleven lives, while 1888-9 shows a reduction of this number to four. The mishaps in question were produced either by collision or stranding. There is no case of capsizing. The American record compares unfavourably with this. Taking the year 1887-8 we find some serious cases of capsizing, which point conclusively to a woful lack of stability. The sloop *Mystery* capsized, and twenty-five lives were lost. The *Gracie* was thrown on her beam ends, and one person was drowned; while the *Olivette* capsized in Newark Bay, and six lives were lost. As showing the risk attendant upon yachting in "shallow" boats of the "skimming dish" type the above figures are conclusive. The *Mystery* was 29ft. 3in. by 11ft. 5in., with a draught of 2ft. 5in.; while the *Gracie* was 70ft. by 21ft., with a draught of 6ft.

Most of the disasters occurring among British yachts are those which happen to small vessels of but few tons. The larger British yachts enjoy an immunity from disaster producing loss of life, that is most remarkable, only one life being lost from boats exceeding 40 tons during the five years terminating with the yachting season 1888-9

The international races between British and American Yachts, besides proving of the greatest interest to the naval architect, stir a national enthusiasm which stimulates invention on both sides of the Atlantic. Their present discontinuance is to be regretted as the inevitable result of the conditions under which the American Cup is offered for competition. English yachtsmen are asked to send the particulars of the boat they propose to enter for the contest, and the nature of the details enables the Americans to build a boat on lines which they think an improvement. Or some three or four boats may be built and the best selected to compete with the foreigner. When the enemy is placed in possession some ten months previously of the length, draught, extreme breadth, breadth on the load water line, and the register tonnage of the challenging craft, he is supplied with data which place him at a very great advantage indeed. To such stringent conditions as these, British yachtsmen can hardly be expected to concede, and until some important modification is arranged international competitions for the possession of the American Cup must cease.

The conditions attached to the international race which our Royal Victoria Yacht Club attempted to arrange are much fairer. The challenger needs only to send an approximate specification of the design of the vessel he wishes to enter. The length on the load line must be stated, and the rating, but a margin of variation of 5 per cent. on the length and 10 per cent. on the rating is allowed.

The American excess of patriotism, which amounts to exclusiveness, makes itself felt in other directions besides excluding competitors from the chance of winning the American Cup.

The protectionist policy, of which the McKinley Tariff Act is typical, affects American ship-owners, and more especially yacht-owners, very seriously. The design of the measure was to foster native ship and yacht building by levying a duty of 50 c. per registered ton every time a foreign-built but American-owned vessel enters a United States port. Visiting yachts are, to a certain extent, exempt from this impost, but if their visit is prolonged over six months then they become liable under the Act. How hardly this tax will fall upon American citizens a single example will show. Mr. Frederick Vanderbilt purchased at Cowes, during the present season, the steam yacht *Conqueror*. Each time he enters one of the United States ports he will have to pay a tax of £40. An American contemporary thus explains the working of the Act so far as visiting yachts are concerned. "If Lieutenant Henn should pay a friendly visit in the *Galatea*, as he did in 1886-7, arriving in August of the former year and staying until October of the latter, he would be compelled to pay duty on his yacht—about 1800 dollars—and, besides this, a tax of 80 or 90 dollars at every port at which he called, besides being liable to a fine of 100 dollars each time he got underway."

Such a measure as this can hardly tend to foster friendly rivalry between British and American yachtsmen, and must inevitably decrease the enthusiasm for the sea and the improvements in shipbuilding which it was intended to foster.

So far as present prospects are concerned international yachting in the future will be confined to contests between British and French vessels. Yachting is quite a new sport in France, but its growth, though rapid, has been phenomenal. It is not so very long ago that the *Eulalie* of 20 tons, built at Havre, was the sole representative of this type of craft in France. Now the popular interest in the nautical pastime is such that a highly successful weekly journal, "Le Yacht," is published, and French yachtsmen are longing to measure their strength with foreign competitors. An energetic and influential committee, formed to further yachting, resolved to offer, in the name of the Comité du Yacht Français, a challenge cup styled "Coupe de France," as the prize of an international race to come off in French waters during the racing season of 1892.

The friction between England and the States relative to yacht racing has given a decided check to the multiplication of large yachts, and both in England and America the feature of the present season has been the development of small yacht racing. The 90ft. sloop which engrossed so much attention along the Atlantic seaboard has gone out of fashion, and the largest class now is the 46ft. boat, which corresponds to the English 20 tonner. The Pacific and the North American lakes have copied the movement initiated in the eastern nautical centres, and nothing but the revival of international racing will bring the big boats into favour again. Whether the present friction will shortly

be smoothed over remains to be seen, but the spirited action of our Gallic neighbours ensures that in one direction at least international yacht racing is not altogether a thing of the past.

SWIMMING ANIMALS.

By R. Lydekker, B.A.Cantab.

(*Continued from page* 168.)

The Divers, Auks, and Grebes are, with the exception of the Penguins, those birds which appear to have been most profoundly modified for a life in the water, being equally at home both on and below its surface. In these birds the short legs are placed so far back that when on land the body is carried in a more or less nearly erect position, as we may observe in the Guillemots and Puffins of our coasts. Although the legs themselves are very short, yet the toes are elongated, so as to convert the feet into very powerful oars. Most of these birds look exceeding awkward when on land, and as they use both their feet and wings in diving, the water is undoubtedly the element in which they are most at home. Speaking of the Red-Throated Diver of Northern Europe, Mr. Dresser observes that "it swims low down in the water, and when uneasy or alarmed will submerge its body below the surface, leaving only the head and neck in view. When it dives it vanishes beneath the surface without noise or flutter, and propels itself along with its wings as well as its feet, frequently remaining for some time before it emerges to view again."

The most remarkable modification which birds have undergone for the purposes of an aquatic life is, however, presented by the Penguins of the Southern Ocean. These grotesque birds, some of which attain a very large size, are even more upright than the Puffins, and when arranged in lines on the cliffs of the Antarctic lands have been compared to regiments of soldiers. Their short wings, which are of course utterly useless for flight, and have but a very limited range of motion, are converted into flipper-like paddles, covered with short bristly feathers, their only use being as additional swimming organs. We have here, therefore, an instance of an organ originally modified for an especial purpose—flight—subsequently undergoing a kind of retrograde modification for a totally different use, although still retaining the structural peculiarities which it presents in ordinary birds. Certain features in the structure of the leg of the Penguins suggest, however, that these birds belong to a very primitive type.

We must not conclude our notice of swimming birds without reference to the extinct *Hesperornis*, of the Cretaceous beds of the United States. This remarkable bird, which was nearly six feet in length, shows evidence of its relationship to reptiles by the retention of a complete series of sharp-pointed teeth in both jaws. In the structure of its bones it appears to come nearest to the Grebes and Divers, but it differs from all the swimming birds in having lost (so far as can be determined) all traces of wings; and thus affords one of several instances where species, long extinct, are in certain respects more specialized than any of their living relatives.

Our remaining examples of Swimming Animals are taken from the class of Mammals, or Quadrupeds, as they are often popularly, though inconveniently, termed. And we shall find that in certain members of this group the adaptation to an aquatic life has been so complete as to have led to the loss of all external features characteristic of ordinary members of the class, and has thus induced the erroneous popular belief that the animals in question are really fishes.

In several groups of Mammals we find that a few species, or genera, have been more or less modified so as to become expert swimmers and divers. Instances of these are afforded by the Australian Duck-Bill (Knowledge, 1890, p. 84) among the egg-laying Mammals, the Otter among the Carnivores, the Beaver and Water-Vole among the Rodents, and the Hippopotamus among the Ungulates. Since, however, none of these depart very widely from the normal type of structure, we may pass to the consideration of two groups, in which all the members have undergone more or less profound structural alterations solely and simply for the purpose of swimming.

Fig. 7.—The Common Seal.

The first of these groups is that of the Seals and Walruses, which form a special division of the Carnivores. Through the spe-

cimens exhibited from time to time in the Gardens of the Zoological Society, most of us are more or less familiar with the external form of the Seals (Fig. 7), and have also witnessed the exceeding gracefulness of their evolutions in the water. In all Seals the limbs are very short, and by the complete webbing of the toes are converted into paddle-like organs. Although the amount of modification is greater in the hind than in the fore limb, yet in both the several digits of the feet still retain their external distinctness. In the so-called Eared-Seals (from which the seal-skin of commerce is alone obtained) and Walruses the hind feet are turned forwards beneath the body when the animal is on land, after the ordinary manner. In the true Seals, however (Fig. 7), these feet are always directed backwards, and thus act solely as propellers in the water. All the Seal tribe are clearly very closely allied to the ordinary land Carnivores; and the Eared-Seals and Walruses indicate the mode in which such animals have undergone a progressive modification until the extreme specialization of the true Seals has been attained.

The second group, containing the Whales, Porpoises, Grampuses, Dolphins, &c., differs so remarkably from all other Mammals that it has been referred to a distinct order—the Cetacea. All the members of this group (Fig. 1) have, indeed, assumed such a completely fish-like appearance that it is even now frequently difficult to convince people that they are true Mammals. Their mammalian nature is, however, shown by their warm blood and four-chambered heart, by the circumstance that they produce their young in a living condition and nourish them by milk drawn from the udder of the parent, and also by their respiration being effected by the aid of lungs. The "spouting" of Whales as they come to the surface is, indeed, mainly due to the water of the sea being thrown up as the air from the lungs is forcibly expelled from the nostrils before the animal has quite reached the surface. We may add that the certainty that Whales are true members of the mammalian class is one of the strongest reasons against employing the term "quadrupeds" to denote that division of Vertebrates.

Although, as aforesaid, the general appearance of a Whale or Porpoise is fish-like, yet a more careful examination shows certain very important points of difference. In the first place, the tail-fin, or "flukes" as it is termed by whalers, is expanded horizontally instead of vertically. The reason for this horizontal expansion appears to be owing to the necessity the Whale is under of coming rapidly to the surface for the purpose of breathing; the upward and downward strokes of the powerful flukes being admirably suited to effect this object with the greatest speed. Then, again, the number and structure of the paddles and fins is quite different from that obtaining in fishes. Thus, a Whale (using this term for the whole group of allied animals) has only a single pair of flippers (Fig. 1), which correspond to the fore limbs of ordinary Mammals, and to the pectoral fins of fishes. These, however, although presenting certain peculiarities, are evidently modifications of the normal mammalian fore limb, and are devoid of any structures corresponding to the fin-rays of fishes. They have lost all outward trace of the digits, being completely invested in a common integument. Then, again, the pelvic fins of fishes are wanting; the only traces of hind limbs being certain rudimentary bones found deeply bedded in the flesh of some of the species (Knowledge, 1891, p. 24, fig. 2), which represent the aborted hind legs of quadrupedal Mammals. If, moreover, Whales have any unpaired fins the single one is situate on the back (Fig. 1), and its structure is quite different from that of the dorsal fin of a fish. In order to enable them to stay for long periods below the surface, the circulatory system of Whales develops a number of net-like arrangements of the vessels in which a supply of fresh blood is stored up.

It would involve too much detail to enter into the consideration of the numerous other resemblances existing between Whales and ordinary Mammals, but there can be no sort of doubt but that they are members of the class; and likewise practically none that they are descended from a group of originally terrestrial forms, the special modification having in this case been carried to a considerably greater degree than in Seals, which we know have undergone an analogous development. Naturalists are, indeed, not altogether in harmony as to the kind of terrestrial Mammals from which Whales have descended, but the probability is that such ancestral types were more nearly allied to the pig-like Ungulates than to any other type of Mammals with which we are acquainted. The Hippopotamus shows us how a pig-like animal may become amphibious, and there is no reason why a further development should not go on. It will, however, be understood that the terrestrial ancestors of the Whales have long since disappeared from the face of the earth; and it should be added that not a trace of the intermediate connecting forms has yet revealed itself to reward the anxious search of the palæontologist. The Cetacea are first known in the upper part of the Eocene division of the Tertiary period, and it thus seems quite clear that they were developed to fill the gap left in the life of the ocean by the disappearance of the Ichthyosaurs and Plesiosaurs at the close of the secondary period; the general replacement of a lower by a higher type of organization being apparently the great life-feature by which the early part of the former period is distinguished from the latter.

THE DIAMOND MINES OF SOUTH AFRICA.

By Vaughan Cornish, B.Sc., F.C.S.

The first South African diamond was found in 1867, and during the next three years diamonds were obtained from the river workings. In 1870, the *mother rock* was found at Kimberley. This rock occurs in pipes as they are termed, round or oval funnels with a surface area of several acres, and of great but unknown depth. Some have already been excavated to a depth of 800 feet without any sign of reaching a bottom, or bed rock. The rock first worked at and near the surface is termed the yellow ground, a friable material from which the diamonds are readily extracted. When the yellow ground was worked through and the *blue rock* struck, many of the miners imagined that the deposit was worked out, and abandoned their claims. Others filled in the excavations with the *yellow*, and sold their claims to less knowing but more fortunate adventurers. The "blue" proved to be the real matrix of the diamond, the "yellow" being merely the blue rock altered by weathering, a yellow colour having been produced by formation of oxide of iron from the action of the atmosphere on the highly ferruginous rock. The blue is a volcanic rock of very peculiar character, extremely heavy, and of the structure known as *brecciated*, characteristic of a volcanic rock which has been subjected to movement after hardening. It contains boulders of all sizes up to twenty tons, and pieces of sandstone, shale, and occasionally fragments of fossil trees. A detailed study leaves no doubt that the *pipes* are of eruptive origin—a pipe being, in fact, the neck of an old volcano—and that the blue was

forced up from below, the sandstone and so forth which show evidence of aqueous action being undoubtedly derived from the material of the formerly existing rock. This point has an important practical bearing, as an aqueous deposit must be bottomed sooner or later, which is scarcely likely to occur in the case of an eruptive formation; hence the probability that the supply of diamonds will continue to hold out. The extraction of the diamonds from the blue is less readily effected than from the yellow surface material. The blue rock is first spread out on the surface and exposed to the action of the weather. The disintegration proceeds best when wet and fine days alternate, and in dry weather the process is hastened by watering the material. The change which occurs is the same as that which produced the yellow at the surface of the pipes. When the process has gone on sufficiently long, the rock is treated by the washing machinery. The lighter materials are washed away in a pulsator, and the diamonds and heavier minerals, such as pyrites and garnet, are left in a sort of mud, which is brought on to a table and carefully searched. Comparatively few diamonds are discovered during the actual mining of the rock; they are imbedded singly, and are not conspicuous objects. The general appearance of the natural diamond is somewhat like that of a piece of white gum—the brilliancy of the stone being only called out by the operation of cutting. Naturally the stones most likely to be noticed are those of large size, and it is these which are the great prizes of diamond mining, since the value of a stone rises in a very rapid ratio with the size.

Now that the mining is no longer done by private adventurers, but the whole worked under one management, it is extremely important to ensure that the workers shall not secrete the stones. The miners, when they come up at the end of their shift, are carefully searched. As the natives work without clothes it might be supposed that the searching would be a very simple matter; it is not so, however, the hair, ears, and teeth being used as places of concealment. The stones were frequently swallowed, which led to the system of keeping the native workers in compounds, which they are not allowed to leave during the term of their engagement. No spirits are allowed in the compounds, where the "boys" are well taken care of. The life, with its order, and enforced discipline, often exercises a beneficial effect on the characters of the natives, making them sober and saving. The laws against receivers of stolen diamonds are very severe, I.D.B.'s (illicit diamond buyers) being sentenced to six or even ten years' hard labour. Most of the work at the larger mines is done by contract, the company paying so much a load, and providing and housing the native labourers, who are paid by the person undertaking the contract—generally himself an experienced miner. There are about seven natives to one white man in the mines: of the whites some 60 per cent. are British, about 4 per cent. other Europeans, or Americans.

Now that the mining is carried on at great depths, the risks of accident are considerable. Till a depth of about 400 feet was reached the system of open workings was followed, but as the depth increased the falls of the blue rock became more frequent. Zulu watchers were stationed to give warning to the miners when the rock showed signs of giving way. This kind of work involving constant alertness during long periods of inaction is peculiarly trying to white men, but is admirably performed by the Zulus.

The appearance of the mines from above is that of huge craters, at the bottom of which the tunnelling and shaft-sinking commences. A depth of some 800 feet has been reached in some of the mines. The mode of descent into these huge craters is simple and expeditious, but not suited to nervous passengers. A kind of truck or tub is suspended below two wire ropes, the flanged wheels, which are, of course, above the tub, running on the ropes. The tub is attached by a third wire rope to a winding engine, the rate of winding being about 40 feet a second, or nearly 30 miles an hour.

The average weight of diamonds obtained per load (16 cubic feet) of blue rock varies greatly in the different mines; the ordinary limits may be put at $\frac{1}{5}$ and $2\frac{1}{2}$ carats. Those mines which have the largest number of stones do not generally produce the best quality, so that in the matter of profit there is a sort of compensating arrangement. The comparatively new Jagersfontein mine sends stones of finer quality than the better known Kimberley and De Beers mines. During 1889 the total output of diamonds from South Africa was four million carats, or about $\frac{1}{5}$ of a ton, the value of which may be estimated at rather more than £1 per carat, or more than four million pounds sterling. The finest diamonds at present in the market come from South Africa—notwithstanding the popular prejudice which assigns all diamonds of "the first water" (a term, by the way, which is not customary among diamond merchants, though dear to lady novelists) to the mines of Golconda or Brazil. Diamonds, exceeding the Koh-i-noor in size and equal in brilliancy, have been found in the South African mines, but such stones are no longer sought after. Their price, calculated to rise rather more rapidly than the square of the weight, is nominally very great, but no one will pay the price; and, strange as it may seem, such stones are now split up into two or three of the largest size that are ordinarily worn. The "crowned heads" are apparently now all furnished with crowns, and diamonds of a size which seems only suitable for regalia can no longer be disposed of.

To the mineralogist the chief interest of the South African mines lies in the fact that the blue rock, or "kimberlite," appears to be the original matrix of the diamond. Till of late years the diamond had only been found in alluvial deposits, its mode of occurrence giving no indication of its mode of formation. In kimberlite, however, it appears *in situ*, and the character of the minerals with which it is associated may perhaps afford some guidance as to the means to be adopted for the reproduction of diamond. The rock belongs to the class termed ultra-basic, having a low percentage of silica and a high specific gravity. The analogy of the rock to certain meteorites has been referred to in a previous article.

The following are the principal minerals of the rock:—

Biotite	Ilmenite
Bronzite	Olivine
Chrome diallage	Perowskite
Chrome iron ore	Pyrites
Garnet	Smaragdite
Graphite	

The olivine occurs in large quantity. This mineral, under the action of weathering, is decomposed, forming serpentine. In studying the occurrence of diamond-bearing sand and deposits in different parts of the world, the late Professor Carvel Lewis arrived at the conclusion that diamond-bearing deposits occur, as a rule, in water-courses which take their origin in mountainous tracts characterized by the presence of serpentine. Serpentine, or a rock which weathers to serpentine, was considered by Lewis to be the real matrix of the diamond. The position and mineralogical character of the kimberlite rock, filling in the neck of a volcanic vent, plainly show its igneous origin, and the fact that it has

been protruded from below. It is not definitely known whether the diamonds were already formed in the rock before its eruption, or whether they had been produced by alteration of the materials contained in the rock displaced by the eruption. It is worthy of notice, however, that a black shale forms one of the surrounding rocks, and pieces of this shale have been found baked and otherwise altered in the "blue rock." The suggestion has been thrown out that the diamonds were formed by the alteration of the carbonaceous matter of the shale, under the influence of a moderately high temperature and great pressure. Such indications of origin are useful as affording suggestions to the experimentalist, to whom, however, in spite of previous failures, we must still look to tell us definitely how the diamond is formed.

Note. I am indebted for most of the information on the methods of working in the mines to my friend Mr. A. R. Sawyer, A.R.S.M., formerly one of H. M. Inspectors of Mines, now resident in South Africa.

ON THE DISTANCE AND STRUCTURE OF THE MILKY WAY IN CYGNUS.

By A. C. Ranyard.

I AM indebted to Dr. Max Wolf, of Heidelberg, for the beautiful photographs of the Milky Way which illustrate this paper. The large plate, which represents the region about α Cygni, is enlarged from a photograph taken with an exposure of thirteen hours and five minutes, given on two successive days—viz.: 1891, September 9th, 9h. 0m. to 15h. 30m., and September 10th, 9h. 0m. to 15h. 35m.—with a camera of 134 millimètres (that is, about $5\frac{1}{4}$ inches) aperture, and a focal length of 770 millimètres (that is, about $30\frac{1}{3}$ inches). The camera, therefore, is of about the same focal length as the cameras used by Mr. Russell in Sydney, and Professor Barnard at the Lick Observatory, though the pencils of light falling on Dr. Max Wolf's plate were only about three-quarters as intense as those falling on the plates in the cameras of the Sydney and Lick Observatories; the aperture of Dr. Max Wolf's camera being 5·277 inches, as compared with a full six inches of aperture at the Lick and Sydney Observatories. During the long exposures Dr. Max Wolf was relieved by Messrs. Staus and Rosenplaenter in keeping the camera continuously directed to the region photographed. It will be seen that in all three plates the motion of the stars has been very satisfactorily followed.

The region shown in the large photograph is specially interesting for many reasons. It is a region rich in red stars, and also rich in the small class of stars which show bright lines in their spectra, and are known as Wolf-Rayet stars. It corresponds to the northern end of the great rift which divides the Milky Way into two branches throughout half of its course round the heavens, and it is a part of the Milky Way crossed by the zone of large stars referred to in the May and July numbers, as probably being at about the same distance from us as the Milky Way stream of nebulous light and small stars. Dr. Gould, speaking of this zone of large stars, says: * "Few celestial phenomena are more palpable than the existence of a stream or belt of bright stars traceable with tolerable distinctness through the entire circuit of the heavens, and forming a great circle as well defined as that of the Galaxy itself, which it crosses at an angle of about 20° in Crux and Cassiopeia. Traversing in the southern hemisphere Orion, Canis Major, Argo, the Centaur, Lupus and Scorpio, it pursues its way in the northern through Taurus, Perseus, Cassiopeia, Cepheus, Cygnus, and Lyra, its line being less obviously continued by the stars of Hercules and Ophiuchus."

It will be noticed that the two large stars in the picture (α and γ Cygni) are surrounded by a nebulosity very similar in appearance to other masses of nebulosity evidently associated with small stars. Thus the lower portion of the bright cloud to the right hand of the picture is composed of a milky nebulosity evidently associated with the stars which lie along its curving border, while the upper part of the same cloud-mass is more granular, and seems to consist of a multitude of small stars on a background of fainter nebulosity. The association of these large stars with nebulosity which certainly, in the case of γ Cygni, seems to extend into and form a part of a larger nebulous mass evidently associated with the small stars of the Milky Way, is another important link in the chain of evidence tending to show that the zone of large stars above referred to is at the same distance from us as the small stars of the Milky Way.

The star α Cygni is of the 1·5 magnitude according to the Harvard Photometric Catalogue, and we may safely assume that the smallest stars shown on the photograph which seem to be associated with the cloud-masses are not brighter than the 18th magnitude of the photometric scale. A difference of $16\frac{1}{2}$ magnitudes between two stars at the same distance from us, means that the brighter star must be giving about four million times as much light as the smaller one; that is, if the larger star had a photosphere as bright as the photosphere of our sun, and a diameter ten times as great, so that it gave a hundred times as much light as our sun, the small stars would, if they had photospheres as bright as the photosphere of our sun, have a diameter only a little greater than half the diameter of the earth.†

Thus, unless we suppose the diameter of α Cygni, and the other large stars associated with the Milky Way, to be enormously great, or unless we suppose them to be intensely bright compared with our sun, the smaller stars associated with them in the Milky Way must be very minute compared with our sun. The actual size of these suns is a matter of considerable interest to us, for if we knew the size and brightness of any of these stars, or if we could make any approximate estimate as to their light-giving power, we should have a means of determining the distance of the Milky Way. Thus, if we knew that α Cygni did not give a hundred times as much light as our sun, we should know that this region of the Milky Way could not be ten times as distant as α *Centauri*, our nearest neighbour amongst the stars, for our sun would probably appear less than a star of the 1·5 magnitude if it was removed to a distance from us equal to the distance of α *Centauri*.

Unless, therefore, we are prepared to believe that α Cygni, and all the other large stars associated with the Milky Way, are on altogether a different scale from our sun, as well as from α *Centauri* and the other stars whose magnitude or brightness we have been able roughly to estimate, we must assume that the Milky Way is not more than ten times as distant from us as α *Centauri*.

Figs. 1 and 2 have been made by a photographic process so as to show the chief stars in Cygni, recognizable in the two photographs on our second plate. With the

* *The American Journal of Science*, vol. viii., p. 333.

† If, on the other hand, the 18th magnitude stars associated with α Cygni are as large and as bright as our sun, α Cygni itself would need to have a diameter as great as the diameter of the orbit of Saturn, if its photosphere was only as bright as the photosphere of our sun.

North.

The Region of the Milky Way about α Cygni.

Enlarged from a photograph taken by Dr. Max Wolf, of Heidelberg, with an exposure of 13h. 5m., on the 9th and 10th of September, 1891.

North.

The Region of the Milky Way about ε Cygni.

From a photograph taken by Dr. Max Wolf, of Heidelberg, with an exposure of two hours on the 13th July, 1891, and an exposure of three hours on the following day.

North.

The Region of the Milky Way about α Cygni.

From a photograph taken by Dr. Max Wolf, of Heidelberg, with an exposure of three hours, on the 1st June, 1891.

Direct Photo Eng. Co., Limited, 9, Barnsbury Park, N.

exception of the letters and numbers upon them they are absolutely untouched. Fig. 2 very nearly corresponds with the region comprised in the large plate, and it will enable our readers to recognize on the heavens the chief patches of light and the brighter stars shown in the photographs. They are at present very conveniently situated for evening observation. The brighter stars in the curious circle of stars to the right hand, or preceding side of the line joining ε and λ Cygni, will at once be recognized with an opera glass.

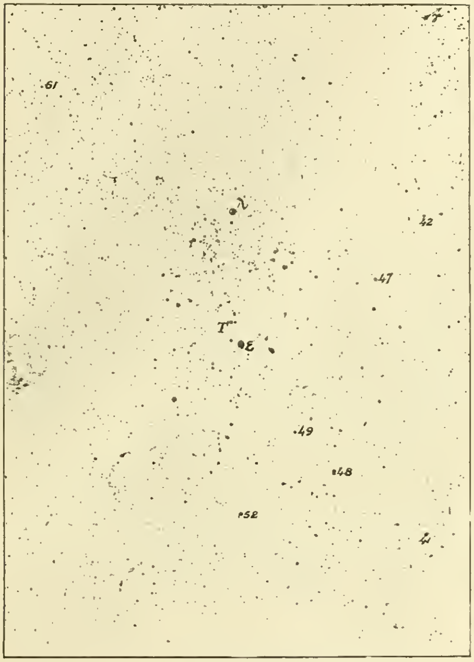


Fig. 1. Index map, made from Dr. Max Wolf's photograph, showing the principal stars about ε Cygni.

On Dr. Max Wolf's photographs the region within and just around this little circle of stars is darker than the rest of the field, and it is connected with a dark channel which passes across the nebulous area close to ε Cygni. It seems to be part of a dark branching structure which springs from the darker region on the preceding side of ε Cygni.

Fig. 2. Index map, made from Dr. Max Wolf's photograph, showing the principal stars about α Cygni.

A similar dark branching structure is well shown on our large plate a little to the north of α Cygni, and it is traceable running northward to near the top of the plate, and again branching. This is due to no photographic defect, for it is clearly visible on three different photographs of this region which have been sent me by

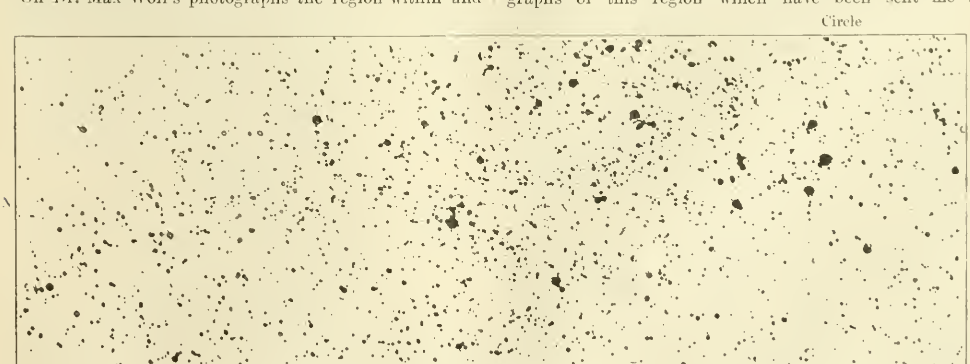


Fig. 3. Zinc photo-etching of a part of the ε Cygni photograph, on double the scale of the plate.

Dr. Max Wolf, and there are similar dark tree-like structures to be traced on Prof. Barnard's photograph of the Sagittarius region, a copy of which was published in the July number of Knowledge for 1890. Two of the most remarkable of the dark branching structures in the Sagittarius region spring from the dark area between the two clusters of stars near the bottom of the plate, and from this same dark area springs the bright tree-like form referred to on page 51 (Knowledge, March, 1891) as affording evidence of the projection of matter into a resisting medium.

It will be noticed that the dark channels and dark branching structures referred to are all bordered by lines of stars, which mark out their contour, just as the dark areas around η Argus are bordered by lines of stars. There are three striking dark patches, irregularly bordered by stars, near to the edge of the upper portion of the bright cloud-like mass to the right hand of the α Cygni picture. They are best shown in the large plate, though they are just visible in the small one. These dark patches remind one of the small dark hole bordered by stars in the Sagittarius region (see Knowledge, July, 1890, p. 175). The lowest of the dark patches on the Cygni plate has an elliptic-shaped group of small stars near its centre, surrounded by a dark elliptic channel. The patches seem to be connected together, and to form part of a dark structure, springing from the dark area to the south of α Cygni.

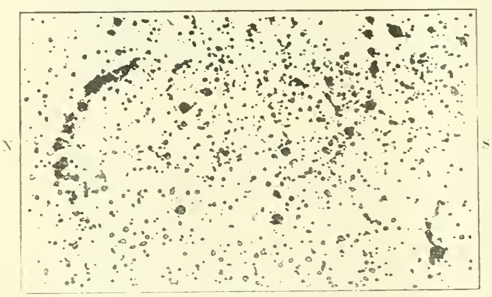


Fig. 4. Lightly etched plate, showing curving nebula and nebulous branches from 52 Cygni.

A remarkable series of slightly curved lines or strings of stars will be seen near to the top of the ϵ Cygni plate. The plate should be held sideways to see them best, as they run nearly vertically, that is, north and south upon the plate. I have made an enlarged photograph of this region, which I have had etched upon a zinc block (Fig. 3), but as many of the small stars are lost, the lines of stars are not as strikingly shown as upon the plate. It, however, shows a very curious little circle of stars, with radial streams, near to T Cygni. The radial lines of stars are evidently connected with the little circle of stars from which they radiate. The word "circle" is printed just above the small circle of stars on the block, but its striking character is best recognized on the plate.

That these curves and allineations of stars are not fanciful forms or chance arrangements, such as might be detected in the grouping of small objects thrown down at random (such as drops of rain falling on a paving stone), will be evident directly we consider the question from a probability point of view. Many of these star-streams contain twenty or thirty or more stars of about the same magnitude, following one another in a straight or curving line, at approximately equal intervals. If we assume that the chance is one to four that a point thrown down at random would appear to fall into line with two points already in position, the chance against ten such points falling into line with two already in position, so as to form a smooth curve, would be more than a million to one, and the chance against twenty such points falling into line would be more than a million of millions to one. This is much understating the improbability, for leaving out of consideration the chance that a series of adjacent stars having no physical connection should all be of nearly the same magnitude, and at about equal spaces from one another, the chance that the next adjacent star should fall into line with a series already in a straight or curving row must be less than $\frac{1}{12}$th, for the eye would certainly detect irregularities or deviations from the general trend of the curve amounting to 30°. We might, therefore, without any further evidence, take it as established that there must be an intimate connection between the stars of such a stream, and that they must have had a common origin, and form a system. But in the Pleiades cluster we have ocular evidence of a physical connection between the stars forming two such streams. The individual stars are connected together by a narrow nebulous band, "which threads them together." Prof. Pickering has also succeeded in photographing a faint nebulous band of light in the Orion region which passes through sixteen faint stars.* We have also some evidence of a similar connection on Dr. Max Wolf's

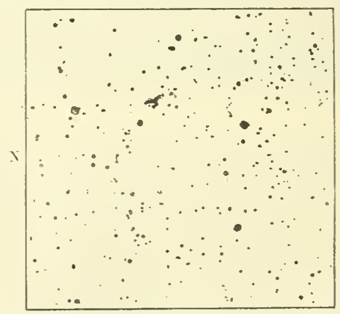


Fig. 5. Deeply etched block, showing stars involved in curving nebula.

ϵ Cygni photograph: I have had the small etchings, Figs. 4 and 5, made from a part of this plate, which shows a curving nebula involving stars. Fig. 4 has been lightly etched so as to show the nebulous band, and Fig. 5 has been more deeply etched so as to show the stars involved in the nebula and linked together by it. Fig. 4 also shows traces of two nebulous branches from the star 52 Cygni. It will be seen that small stars lie along these curving branches and appear to be connected together by them.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

THE OBSERVATION OF RED STARS.

To the Editor of Knowledge.

Dear Sir,—I fully agree with Mr. Franks that no demonstrative proof of colour instability in non-periodical stars is at present forthcoming. Nor is his scepticism

* See "Annals of Harvard College Observatory," vol. xxvii., p. 155.

without warrant from experience, since spurious instances of this kind of change might be counted by the dozen. What I would urge, accordingly, is not that any single alleged fact bearing on the point should be taken as established, but that a more determinate plan of investigation should be adopted than has hitherto been in use. Few will deny that a strong case for further enquiry has been made out. The evidence at hand is at any rate of sufficient weight for the purpose of directing special attention to certain objects, the rumoured colour-variations of which can be tested only by patient watching. Now, under this system, sundry processes of variation undoubtedly tend to become arrested, which seemed to show decidedly enough in the twilight of casual notice. Whether or not the changes imputed to red stars will fall into this category, remains to be seen. My personal conviction is that some of them will prove genuine, but it is founded, I admit, on a scanty basis of experience. Nevertheless, *r* Velorum made so striking an exception to the otherwise unfailing and emphatic redness of Gould's "red stars," so far as I was able to review them at the Cape, that I find it difficult to conceive of the change as apparent only. Properly speaking, however, all observations of this nature yet recorded ought to be regarded as merely indicative. A fresh start should be made with a view to ascertain—first, whether colour-variations really occur; secondly, what is their cause, if they do occur. Not that these two enquiries need be prosecuted separately or successively; the better plan would be to carry them on at the same time, and by the same means. In neither should the telescope be implicitly relied upon. The data afforded by it should have their meaning probed and deepened by the concurrent aid of the spectroscope. A useful adjunct, moreover, might be found in the photographic determination of relative magnitudes; for changes of tint would presumably be accompanied, and might even prove to be strictly measurable, through changes in the chemical intensity of the emitted light.

A. M. Clerke.

Ballysodare, Co. Sligo, Ireland,
18th September, 1891.

Dear Sir,—Looking over your interesting paper on the Pleiades in the May number of Knowledge, I was surprised to see that in your list of first magnitude stars (p. 91) you give Canopus only sixth in order of brilliancy! From my own observations in India I have no doubt that, with the exception of Sirius, Canopus is certainly the brightest star in the heavens. Indeed, on one or two occasions I found it very little, if at all, inferior to Sirius. Gould gives ("U.A.," p. 312) the order of brightness:

Sirius	0·1	Arcturus	0·8
Canopus	0·4	α Lyræ	1·0
α Centauri ...	0·7	Rigel	1·0

and, setting aside α Centauri (with which I am not familiar), this is the order in which I should place them.

I am aware that there is a difference of opinion with reference to the relative brightness of Arcturus, Capella, and Vega, but to anyone who has seen Canopus there can, I think, be no doubt that it is brighter than any star in the northern hemisphere. I am aware that it has been suspected of variation—some observer in Chili, in 1861, thinking it brighter than Sirius!—but in its normal state it should, I think, certainly stand second on the list.

Yours very truly,
J. E. Gore.

I see in the "Cape Observations" Sir John Herschel gives the following sequence, observed March 28th, 1838:

At Sea. Crossing the Line.

Sirius ..	0·10	η Argûs ..	—
Canopus... ...	0·22	Rigel ...	0·76
α Centauri ...	0·34	Procyon ...	0·85
Arcturus ...	0·45	α Orionis	1·00

[I have given the readers of Knowledge the benefit of Mr. Gore's letter, though I imagine that it was not written for publication.

Accurate photometric measures of the brighter stars in the southern heavens are much needed. The magnitudes given in the article referred to are from Prof. Pickering's "Photometric Catalogue for the Northern Sky" and from the "Uranometria Argentina" for the rest of the heavens. There must surely be some mistake about the estimates of Gould and Sir John Herschel of the brightness of *Sirius*. But if we adopt their order of magnitude, it makes no difference in the fact to which I wish to draw attention—that out of the twelve brightest stars in the heavens seven lie in the brilliant girdle of stars referred to, and three are intimately associated with it, being situated only just on the opposite border of the Milky Way.—A. C. Ranyard.]

ARE THE LUNAR RAYS DYKES, OR DUE TO FISSURES?

To the Editor of Knowledge.

Sir,—The paper on "Lunar and Terrestrial Volcanoes," in Knowledge, August 1st, pages 145-7, and your remarks thereon, are most interesting to students, and I trust you may allow me a small space for a few words about the rays.

With Mr. Hutchinson's conclusion, that the long white streamers radiating from Tycho and other craters cannot be due to "faults," most selenographers, who understand a little geology, will at once agree.

A fault is not only a fissure, but also a more or less vertical "slip," or dislocation, of strata, which leaves one side much higher than the other; hence, if the rays were due to faulting, we should (frequently) be able to detect this inequality by the shadows at sunrise and sunset.

As a matter of fact this feature is not seen in the rays, and, when we realize their width, this explanation of them may be safely set aside as untenable.

Mr. Hutchinson inclines to look on the rays as trap dykes, or vast cracks into which some white molten rock has been extruded; but, as you have clearly pointed out, they are far too wide and indefinite along the edges to permit of this as a solution.

As Prebendary Webb so clearly points out, page 74 of his "Celestial Objects," "the chances against so general and exact a restoration of level, all along such multiplied and most irregular lines of exposure, would be incalculable."

If the rays were due to vast fissures, filled in with whiter material, the distortion (by displacement) of the detail would be quite extraordinary. Where a ray-dyke, ten miles wide, cut a cleft or ridge at an acute angle, the severed extremities could not possibly remain in line.

The entire region around Tycho, especially to the west, would in fact have been so revolutionized by the vast fissures and dykes, that the normal detail would have been *utterly obliterated* if the rays were due to this cause.

So that this also, as a solution for these singular white streamers, may safely be put aside as untenable.

With regard to the view that they may be due to snow deposit, along the margins of minute *fissures*, we are at once met by the difficulty of understanding how they come to be so long, so radially grouped, and so minute as to be nowhere visible. The difficulty, again, of conceiving such

a sustained uniformity in the discharge of vapour over such long lines seems to me insurmountable.

If the rays were occasionally interrupted by blanks, or if we could, even in a few cases, detect the fissure, this solution would appear more likely, inasmuch as the visible "clefts" are so obviously fissures in the crust, whence, here and there along their course, vapour has been given off which has been piled as snow cones, or little rings, called craterlets.

But there is no evidence of a fissure, as far as I am aware, in any of the rays, nor can we trace any evidence of a piling up, as in the strings of craterlets; the ray is simply a whitish streamer destitute of all structure, and which nowhere *deforms* the detail or modelling.

It is conceivable that among 1000 rays *one* might be due to a fairly straight (and continuous) minute fissure, whence aqueous vapour had been *so equably exhaled all along* as to give the appearance of a white streamer, as the snow was deposited on each side. That two such cases should occur would, however, be remarkable, and that *all* should present such a combination of features seems to me really incredible.

If we compare, in plan, the lines of fissure passing out from our great terrestial volcanoes (such as those figured on page 142 of Judd's "Volcanoes"), with the lunar ray systems, we at once see a radical difference. In our case the lines are not only strongly curved and branched, like rivers, but occasionally fork at right angles and terminate generally in *branchlets*, like a tree top, a feature which is quite foreign to the rays, as far as I am aware.

The rays, as a rule, appear to be solitary tracks, and this seems to me to preclude the idea of their being due to fissures, the more so as the visible "clefts" on the moon are often branched, forked, or crossed.

So that neither faults, trap-dykes, or fissures, exuding aqueous vapour, would seem to solve this perennial enigma.

Sibsagar, Assam, India. S. E. Peal.
August 28th, 1891.

[I do not think, with Mr. Peal, that the "clefts are so obviously fissures in the crust." Mr. Neison was inclined to regard them as the dry beds of lunar watercourses or rivers. At page 72 of his book on "The Moon," Mr. Neison says: "With regard to the true nature of these rills or clefts absolutely nothing is known, whilst they are too delicate objects to allow much, if any, of the details of their formation to be made out. It has been supposed they are cracks or fractures in the lunar surface, but their intersection and general conditions of existence seem quite inconsistent with such a supposition, more especially in their behaviour with reference to the various formations they pass through, round or over. In many points they bear some resemblance to the dried beds of lunar watercourses or rivers, but in many features do not seem in accord with such an origin, though perhaps it presents the most feasible explanation of their nature of all." We should not see such cracks in the lunar crust unless they were at least a quarter of a mile broad, and it does not seem to me probable that the precipitous sides of such cracks would stand (even under the action of lunar gravity) if the cracks were many miles in depth. The sides would fall together unless they were supported by pressure from the opposite precipice at very frequent intervals. One can conceive of such a deep crack filled with *débris*, or of a fault many hundred miles in length, if the opposite sides pressed against one another at sufficiently frequent intervals to give support. It is clear that the lunar rays have some connection with the volcanoes from which they radiate, and the theory which seems to me most probable is that they correspond to radiating cracks or faults which would not be seen from the earth.

Into such a fault or crack the lunar atmosphere would enter, however rare it may be at the surface, and it would be considerably compressed at great depths. We know that on the earth the atmosphere sinks into the interstices of the soil, and that on every fall in barometric pressure it rushes forth again, laden in many mines with gas. Everyone is familiar with the earthy smell of the air after a shower of rain, when the lowered pressure of the barometer allows the air which has been forced into the soil to rush back to the surface. No doubt the lunar atmosphere is similarly compressed into the soil, during the course of every lunar day, owing to the increased weight of the lunar atmosphere caused by the evaporation into it of aqueous vapour from the snows exposed to the direct heat of the sun. The air would be forced more freely into such deep fissures and cracks than into the ordinary soil, and it would return to the surface during the lunar night. We may feel sure that the expansion of the air on reaching the surface would cool it, as the air is here cooled by expansion as it blows up a mountain side. This is well known to be the cause of the great rain-fall on mountain tops, for the air, when cooled, will not carry as much aqueous vapour as at a warmer temperature. Similarly the lunar air would be cooled by expansion as it reached the surface, and it would deposit its moisture in the neighbourhood of the vent.

It does not seem to be altogether improbable that air should be pretty equally exhaled along the course of a long fault or fissure. The branching structure figured in Prof. Judd's book on volcanoes, referred to by Mr. Peal, does not represent cracks, but "intrusive masses of dolerite."—A. C. Ranyard.]

THE ABSENCE OF A LUNAR ATMOSPHERE.

To the Editor of Knowledge.

Dear Sir,—While composing a lecture on Astronomy, a few months ago, the following idea occurred to me as a possible explanation of the circumstance that our satellite is destitute of atmosphere.

It is well known that when comets approach the sun, large quantities of the gaseous portion of their contents are repelled by some powerful influence, probably the electrical action of the sun.

If, then, we assume that the earth has, at one time, passed through a sun-like stage, does it not seem probable that it would then exert a similar influence upon the atmosphere of the moon, the result of which would finally be that our satellite would be entirely denuded of her atmosphere?

If this explanation be the correct one, we may expect to find that all the other satellites in our system are likewise destitute of atmosphere, owing to this action on the part of their primaries.

The circumstance, accordingly, that no trace of an atmosphere has ever been discovered in connection with the satellites of Jupiter, furnishes confirmation of the above-mentioned theory.

Alexander C. Henderson.

Mount Pleasant Manse,
Newburgh, Fife, Scotland,
9th September, 1891.

[We have no evidence that gaseous matter is repelled from the heads of comets and driven into space. The polarized condition of the light derived from the tails of comets shows that the light of the tail is principally

scattered by fine particles of dust, which are most probably driven away from the sun (not by electrical action), but by evaporation from their heated sun-lit sides. Every molecule evaporated from a particle towards the sun must give the remnant of the particle a kick backwards (see Knowledge for November 16th, 1883), which would tend to drive the unevaporated remnant away from the sun. It seems very improbable that gaseous matter is driven away from the sun, or the gaseous part of the corona and prominences would be driven away, and the sun would be continually diminishing in bulk.

We do not need to assume altogether different conditions to account for the disappearance of a lunar atmosphere. Our own ocean of atmosphere is continually being drained by the absorption of gas which is stored up in solid form, while there are other sources from which the atmosphere is continually being recruited. If, owing to some change, such as a change of temperature, the supply of gas to the atmosphere were to fall below the quantity which is continually being taken up and stored in solid form, the amount of our ocean of atmosphere would be diminished, and it might ultimately be drawn so low as to fall below the amount of the lunar atmosphere by the action of chemical changes such as are at present going on.—A. C. Ranyard.]

ON SOME PECULIARITIES OF THE VARIABLE STARS.

By J. E. Gore, F.R.A.S.

The long period Variable Stars have periods ranging from 100 to over 700 days, and with fluctuations of light from about one magnitude to over eight magnitudes. Dividing these into groups, I find that the maximum number is found among those with periods of 275 to 375 days. Chandler finds that the longer the period the redder the tint. According to Chandler's estimates of their colours, the reddest of all are —in order—R Leporis (period 436 days), V Cygni (461 days), S Cephei (484 days), R Sculptoris (207 days), and V Hydræ (575 days). Dunér, however, makes the reddest variables V Hydræ, S Aurigæ, and V Cygni.

The Variable Stars of short period include 19 stars with periods of less than 30 days. Of these I find that four have periods of under five days, eight have periods of under eight days, three have periods of less than 11 days, and three under 18 days. The maximum number is, therefore, under eight days. The variation of light is usually small. In but few cases does it much exceed one magnitude, and in several it is less. In some, as in β Lyræ, ζ Geminorum, and η Aquilæ, all the changes may be observed with the naked eye alone, while in others an opera glass is necessary to follow their fluctuations.

The great majority of these short period variables are found in a zone which nearly follows the course of the Milky Way. Another curious peculiarity connected with their distribution is that most of them lie—like the Temporary Stars—in the *following* semicircle, that is, between 12 h. and 24 h. of Right Ascension. The most remarkable exception to this rule seems to be ζ Geminorum, which has a period of about 10 days $3\frac{3}{4}$ hours. All the Variable Stars of this class with shorter periods than ζ Geminorum conform to this rule, except S (15) Monocerotis, of which the *regular* variability seems very doubtful. It is not easy to conjecture the cause of this peculiarity of position, for the Variable Stars of other classes are found scattered indifferently over all parts of the celestial vault.

Of the Algol type variables the brightest are Algol, λ Tauri, and δ Libræ. The others are much fainter, only two being visible to the naked eye when at their normal brightness. Chandler finds that "the shorter the period of the star the higher the ratio which the time of oscillation bears to the entire period." Thus, in U Ophiuchi, with a period of about 20 hours, the light changes occupy five hours, or about one-fourth of the period, while in δ Cancri, of which the period is about $227\frac{1}{2}$ hours, the fluctuations of light occupy $21\frac{1}{2}$ hours, or about one-tenth of the period. All the Algol variables are white, or only slightly tinted, and it would therefore seem to be hopeless to look for variables of this class among the highly-coloured stars. In all cases in which the stars have been examined with the spectroscope the spectrum is found to be of the first or Sirian type, another peculiarity worthy of notice. The same remark applies to the stars which have been found by the spectroscope to be close binaries, such as ζ Ursæ Majoris, β Aurigæ, and Spica. These have spectra of the first type, and may be considered as Algol variables in which the plane of the orbit does not pass through the earth.

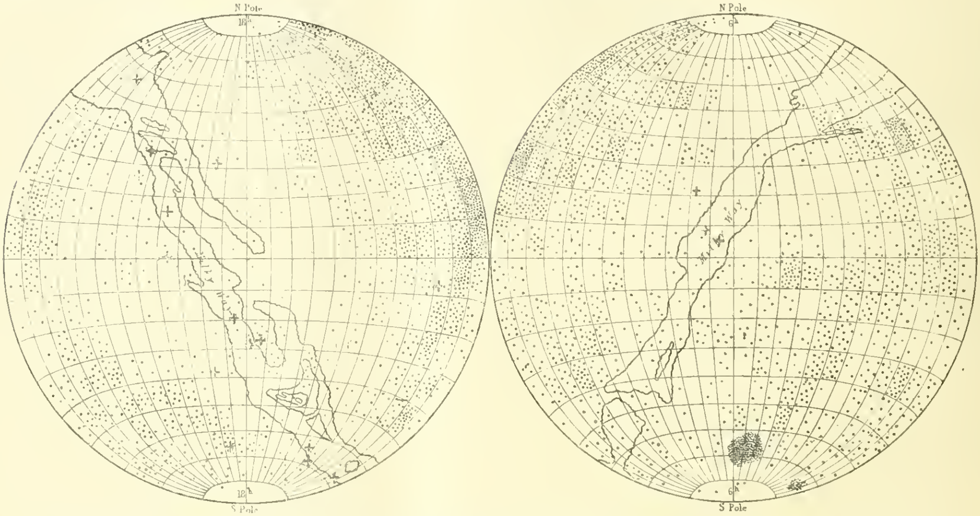
If we assume that the apparent variation of the Algol variables is due to the transit of a dark or nearly dark satellite, we seem logically compelled to conclude that these stars are not really variable at all in the true meaning of the word. Their light is merely obscured at minmum in the same way that the Sun's light is reduced during a partial Solar eclipse. It is simply a case of occultation of one star by another, and probably these so-called variables might more correctly be classed among the binary stars. If, like the Temporary Stars, we reject the Algol variables, we have then only three classes of true Variable Stars, viz. :—(1) stars with regular periods of considerable length, (2) irregular variables, and (3) variables of short period.

With reference to the general distribution of the Variable Stars, I plotted some years since all the known variables on one chart for each hemisphere, and I do not find any *very* marked tendency to aggregation in any particular region of the sky. A marked *paucity* of Variable Stars is, however, noticeable in the northern hemisphere in the constellations of the Lynx, Coma Berenices and Canis Venatici, and in the southern constellations, Canis Major, Columba, Pictor, Eridanus, Fornax, Horologium, Grus, Microscopium, Indus, Toucan, Hydrus and Octans. I notice, however, a tendency to congregate in small subordinate groups. The most remarkable examples of this clustering tendency are as follows :—In and near Corona Borealis, where, in a comparatively small region there are five Variable Stars; near Cassiopeia's Chair, five; in Cancer four, comparatively close together; a small region near η Argûs, containing six; and a limited area near the head of Scorpio, which contains no less than 15 small variables. I find that if the whole sky were as rich in variables as this last-named region there would be about 3000 Variable Stars. The number hitherto discovered has not yet reached 300.

A remarkable peculiarity about the Variable and Temporary Stars is, that few of them show any appreciable parallax. For α Cassiopeiæ and α Herculis a parallax of less than a tenth of a second of arc has been found, but for α Orionis Dr. Elkin finds a negative parallax. These are irregular variables. Observations of Nova Cygni (1876) by Sir Robert Ball, failed to show a measurable parallax. For the new star of 1885 in the Andromeda Nebula, Franz also found a negative parallax. A negative parallax implies either that the parallax is too small to be measured, or else that the faint comparison stars are actually nearer to the earth than their brilliant neighbour. As far as I

know, a measurable parallax has not yet been found for any variable star having a *regular* period. Another fact which may perhaps suggest (although it does not *prove*) great distance, is that few of the long period variables rise, even at maximum, above the range of naked eye visibility. As in the case of most rules, however, there are exceptions to this one; Mira Ceti, R. Hydræ, and χ Cygni being the most notable examples.

The evidence in favour of great distance is further strengthened by the fact that none of the Variable Stars have any considerable proper motion. The list of proper motions greater than one second of arc per annum, given in Miss Clerke's "System of the Stars," does not contain a single known Variable Star. We seem, therefore, to have evidence that the Variable Stars lie at a vast distance from the earth. How is this peculiarity to be accounted for? The only plausible explanation I can see is that the Sun and Solar system do not lie in a region of Variable Stars. The periodical increase and decrease of sun-spots may possibly denote some *small* fluctuation of light in our Sun, but seen from the nearest fixed star, this variation of light, if it has any real existence, would be quite imperceptible, and the Solar light would probably seem to be invariable. Our nearest neighbours in the Sidereal System, α Centauri, 61 Cygni, Lalandi 21,185, Sirius, &c., appear constant in their light, a proof that in a large region of space surrounding the Sun there is not a single Variable Star.



Map on the Isographic projection, showing the place of twenty Short Period Variable Stars with reference to the Milky Way and Nebulæ. The Short Period Variables are represented by crosses and the Nebulæ by dots.

Remarks by A. C. Ranyard.

In order to exhibit to the eye the grouping of the short period variables mentioned by Mr. Gore, I have plotted down the places of the 20 variables of short period referred to on one of Mr. Proctor's pairs of maps, showing the distribution of nebulæ with respect to the Milky Way. It will be seen that 19 out of 20 of these short period variables lie on or near to the region thickly strewn with stars and nebulous matter which we know as the Milky Way. This same region is also rich in red stars and in stars exhibiting bright lines in their spectra, as well as in large and irregular nebulæ, and in star clusters—while the smaller nebulæ seem to avoid it, and to cluster in the poles of the Milky Way. W Virginis, the only one of the short period variables which falls at a considerable distance from the Milky Way, has a comparatively long period of 17·27 days, and its spectrum seems to differ from the spectra of other short period variables.

The distribution of short period variables with respect to the Milky Way was pointed out some years ago by Prof. E. C. Pickering. Miss A. M. Clerke, in her "System of the Stars," p. 145, remarks that within the zone of the Milky Way these short period variables display "an evident disposition towards clustering where the Milky Way divides in Cygnus; the variables follow its southern branch, and they are thickly sown over the whole region from Lyra to Sagittarius." Indications indeed abound, that the conditions of variability and even of particular kinds of variability are localized in space. Thus in Sagittarius no less than four stars fluctuate in periods of six to seven days.

The absence of any appreciable parallax in variable stars need not necessarily be due to their great distance. All modern determinations of parallax are based on measures of the distance of the star whose parallax is sought from small stars in its neighbourhood. If variable stars occur in groups or are situated in clusters of small stars, we should expect to find no relative parallax compared with small stars situated at about the same distance from us as the principal star. We have so few stars showing undoubted parallax that it would be unsafe to base any important general conclusion on the fact that no star of the variable class has yet been discovered showing such parallax; but it is more remarkable that no variable star shows any considerable proper motion. I am indebted to Mr. Gore for the following interesting table.

VARIABLE STARS OF SHORT PERIOD.

Star.	R.A., 1890·0.	Decl., 1890·0.	Variation. Max.	Variation. Min.	Mean Period, Days.	Colour.	Spectrum.	Remarks.
	H. M. S.	DEG. MIN.	MAG.	MAG.				
T Monocerotis	6 19 20	+ 7 8·7	5·8 — 6·4	7·4 — 8·2	27·00	Yellow	IIa. (?)	
S (15) Monocerotis	6 34 55	+ 9 59·7	4·9	5·4	3d. 10h. 38m. (?)	White	Ia.	Period doubtful
ζ Geminorum	6 57 36	+ 20 43·9	3·7	4·5	10d. 3h. 41·5m.	Yellow	—	
R Muscæ	12 35 23	— 68 48·2	6·6	7·4	0d. 21h. 20m.	White	—	
W Virginis	13 20 21	— 2 48·5	8·7 — 9·2	9·8 10·4	17·27263	Reddish	III. (?)	
*T Trian Australis	14 59 29	— 68 17·7	7·0	7·4	1 +	White	—	Variation doubtful
R Trian Australis	15 9 56	— 66 5·5	6·6	8·0	3·4	White	—	
X (3) Sagittarii	17 40 38	— 27 47·2	4	6	7·01185	Yellowish	—	
W (γ) Sagittarii	17 58 0	— 29 35·1	5	6·5	7.59445	Yellowish	—	
Y Sagittarii	18 14 55	— 18 54·5	5·8	6·6	5.7690	White	—	
U Sagittarii	18 25 24	— 19 12·3	7·0	8·3	6·74493	Orange	—	
K Pavonis	18 45 37	— 67 22·3	4·0	5·5	9·097	—	—	
β Lyræ	18 46 1	+ 33 14·1	3·4	4·5	12d. 21h. 46·97m.	Yellowish	Bright Lines	
S Coronæ Australis	18 53 43	— 37 6·5	9·5	13·0	6·2 (?)	—	—	
U Aquilæ	19 23 26	— 7 16·2	6·3	7·3	7·033	—	—	
η Aquilæ	19 46 52	+ 0 43·4	3·5	4·7	7d. 4h. 14·0m.	Yellow	IIa.	
S (10) Sagittæ	19 51 0	+ 16 21	5·6	6·4	8d. 9h. 11·0m.	White	—	
X Cygni	20 39 5	+ 35 11·4	6·4	7·2 — 7·7	16d. 9h. 36.9m.	White	—	
T Vulpiculæ	20 46 34	+ 27 48·9	5·5	6·5	4d. 10h. 29·0m.	White	—	
δ Cephei	22 25 5	+ 57 51·1	3·7	4·9	5h. 8h. 47·66m.	Yellow	—	

* Note.—T. Trian Australis is not included in the 19 Variables mentioned in Mr. Gore's paper, as its variability has not yet been confirmed.

THE PERFUMES OF ANTIQUITY.

By J. Ch. Sawer, F.L.S.

PROBABLY the word "perfume" is derived from *per fumum*, "by the aid of smoke," and originated in that most ancient custom of burning resinous substances and aromatic woods in religious ceremonies, thus creating an odoriferous smoke, which was doubtless of advantage in the early form of worship as a disinfectant or deodorizer in counteracting the offensive odours of the burning flesh of the offerings. In other countries where animals were not slaughtered and burned, the incense no doubt acted on the mystical imagination of the worshipper, its overpowering vapours throwing him into a religious ecstasy conducive to the belief in the acceptance of his prayer as he observed the gradual ascent of the smoke from the altar and its dispersion in space.

The incense ordered for the service of the Tabernacle, to be burned in a censer and on the Altar, consisted of Stacte, Onycha, Galbanum and Frankincense in equal parts.

Stacte (σταχτή), which is the Greek translation of the Hebrew word נטף (nataph), signifies a liquid exudation, or something fluid. Pliny describes it as the natural exudation of the myrrh-tree, flowing without the tree being punctured, and more esteemed than myrrh itself. Theophrastus also mentions two sorts of myrrh, one liquid and one solid.

Onycha is the Hebrew *Schecheleth*, "odoriferous shell." It is the *operculum* of a species of *Strombus*, formerly well known in Europe under the name of *Blatta Byzantina*, found in the Mediterranean and in the Red Sea, from which latter the Israelites no doubt procured it. It is occasionally to be seen at the Custom House of Bombay, where it is imported to burn with incense in the temples, not so much on account of any pleasing odour of its own as to bring out the odour of other perfumes. It is a white transparent shell, resembling in shape the human finger-nail; hence its Greek name ὄνυξ, *onyx*, a finger-nail. It is generally believed that the fish inhabiting this shell acquires its peculiar odour by feeding on a species of Indian Nard.

Galbanum חֶלְבְּנָה (*Chelbenah*). The word signifies something unctuous, and evidently applies to a balsam. According to some authorities it is a fine sort of galbanum found on Mount Amomus in Syria, differing entirely from the ordinary galbanum now used in medicine, of which the odour is anything but sweet. But the fashions of this world change, and if we, in our day, find no sweetness in galbanum, saffron, and spikenard, it is no reason why the ancients did not, and no reason why Orientals should not, even now. At the present day the Persians call asafœtida "the food of the gods," the Russians delight in caviare, and the Esquimaux in train oil.

As an example of the preservation of ancient Jewish customs, galbanum still forms one of the ingredients of the incense now used in the Irvingite chapels in London.

Frankincense.—This is largely imported into London under the name of Gum Olibanum, and is used principally in the manufacture of incense for the Roman Catholic and Greek Churches. The Greek word λίβανος, the Latin *Olibanum*, the Arabic *Lubàn*, and analogous words in other languages are all derived from the Hebrew *Lebonah*, which signifies *milk*, in allusion to the sap of the trees, which, before becoming dry by exposure to the air, has the appearance of milk. This drug was imported into China from Arabia as far back as the tenth century, and is still imported to an enormous extent at Shanghai to this day, under the name of *Ju-siang*, meaning *perfume of milk*, being always in allusion to the meaning of its Hebrew name *Lebonah*.

Olibanum is derived from several species of Boswellia, indigenous to the hot arid regions of Eastern Africa, the southern coast of Arabia, and some parts of India.†

The trees vary greatly in height, averaging about twenty feet; their form is very graceful, and when springing from a massive rock on the brink of a precipice their appearance is very picturesque.

The harvest of this drug in Southern Arabia is thus described by Carter:—"During the months of May and

† An enumeration and description of these trees is given by Birdwood in the "Transactions of the Linnæan Society," xxvii., p. 3, and in the "Journal of the Bombay Branch of the Royal Asiatic Society," ii., p. 380.

December longitudinal incisions are made in the bark; the cuticle and adjacent parts then become shining and distended. When the gum first begins to run it is white as milk, and according to its degree of fluidity runs down to the ground or concretes on the tree near to the incision. It is then collected by the families owning the land." According to Capt. Miles ("Jnl. R. Geograph. Soc.," xlii., 65), the gum is not collected by the inhabitants of the country, but by the Somalis, who come over in large numbers from the opposite coast and pay a tribute to the Arabs for it, gathering it themselves. He considers the Arabian Lubàn inferior to the African.

As found in commerce, olibanum varies greatly in quality and appearance. It occurs in the form of rounded fragments of a pale yellow and sometimes reddish colour, also in pale yellow or nearly colourless distinctly pear-shaped tears, sometimes stalactiform and slightly agglutinated. It is always of a mealy surface covered with a fine white dust, and even where this is wiped off the tears appear translucent and milky. The fracture is splintery; the odour faintly balsamic; the taste bitter.

These four ingredients would doubtless burn readily if cast on the fire of the altar, and probably burn with a flame, but to develop a smoke the ingredients should burn slowly, or smoulder. If burned in a censer an incense of this composition would very likely go out by melting into a solid lump. In modern incense the difficulty is overcome by adding pulverized charcoal and nitrate of potash, but Moses does not specify any other ingredient.

In the description of the composition of the holy incense given in the Talmud (Book "Cheritoth"), we find the words "borith Carshina," which are usually translated "soap of Carshina," but soap would form a very bad ingredient for incense. Soap was unknown to the Jews, and the word "borith" (ברית) is more likely to refer to a natural alkaline production of Judæa, somewhat similar to the Egyptian "natron" or "nitrum," or to the nitrate deposits of Chili. Such an addition to the ingredients would supply the oxygen necessary for combustion.

From Ex. xxx. 22-38 we find that the *holy anointing oil* for the service of the Tabernacle was composed of myrrh, sweet cinnamon, sweet calamus, cassia, and olive oil. The word *myrrh* is derived from a Hebrew word, signifying in French *amer*, and in English *bitter*. It is also said to be derived from the Arabic word *mur*. The Greek equivalent is σμύρνα. The ancient Egyptian word Bola or Bal, and the Sanskrit Vola, are yet preserved in the Persian and Indian names Bol, Bola, and Heera-Bol, well-known names of myrrh. Myrrh is a gum-resinous exudation from the stem of the *Balsamodendron myrrha*, collected in Arabia Felix and Abyssinia, a spiny shrub of which there are at least three distinct species. Good commercial myrrh is in irregular-shaped masses of a reddish-brown colour and slightly translucent. It has a dull irregular fracture and an aromatic and characteristic odour. The Bissa-Bôl, which is an inferior quality and much adulterated, was formerly called East India myrrh and is of African origin, but the plant furnishing it is unknown, although it is said by the natives to much resemble the tree yielding the Heera-Bôl or true myrrh. The variety from which the ancients principally drew their supplies was probably that of Southern Arabia; this has the same odour as ordinary myrrh, and is not distinguished from it in English commerce by any special denomination.

The "sweet cinnamon," called "kinnamon" in the Old Testament and κινάμωμον in the New (Rev. xviii. 13), is Ceylon cinnamon.

The "sweet calamus" (Keneh bosem); the "sweet cane" (Keneh hotteb, Jer. vi. 20), and "calamus" (Kaneh, Song of Sol. iv. 14, and Ezek. xxvii. 19) is, according to some authorities the *Andropogon Calamus aromaticus* of Royle, which is synonymous with the Andropogon Schœnanthus of Linnæus, and known in India as Roosa-grass and in London as "Ginger-grass." This grass grows wild in Central India, in the North-West Provinces, and is abundant everywhere in the Deccan. It has recently been found on the Hurnai Railway route in Baluchistan (Lace in "Jnl. Lin. Soc.," xxviii., 296, Aug., 1891). At the present day this grass is largely used for the distillation of its oil, which is employed in the adulteration of otto of rose.

It is, however, very probable that the "sweet calamus" was the *Andropogon laniger* (Desfontaines). This plant has a wide distribution, extending from North Africa, through Arabia and North India to Thibet. It is the σχοῖνος ἀρωματικὸς of Dioscorides and the Herba Schœnanthus and Juncus odoratus of Latin writers on Materia Medica. The Arabic name is Izkhir, which signifies stored-up forage. It has also been called Fœnum Camelorum, from its use in dry desert tracts as a forage for camels. When cattle eat much of this grass, the milk becomes scented. Lemery, commenting on Pomet ("Hist. des Drogues"), says that "this is a kind of fragrant rush or grass growing plentifully in Arabia Felix, at the foot of Mount Libanus. The stalk is about a foot high, divided into several hard stems, of the size, figure and colour of barley straw, being much smaller towards the top. The leaves are about half a foot long, narrow, rough, pointed, of a pale green colour. The flowers growing on the top are arranged in double order; they are small, hairy, and of a carnation colour . . . . all the plant, and particularly the flower, is of a strong smell and bitter taste."

The other odoriferous ingredient in the holy anointing oil, *Kiddah* (Exodus xxx. 24), is translated *cassia*. In Psalm xlv. 8 it is called *Ketzioh*, and here, undoubtedly, *Cassia lignea* is meant. This is the bark of the *Cinnamomum Cassia*, a forest tree of China. Another variety called Malabar cassia, is exported from Bombay; this is thicker and coarser than that from China. These barks resemble cinnamon in many of their qualities; the smell and taste are nearly the same, but less sweet and more pungent, but the substance is thicker and the appearance coarser and darker than cinnamon. All these barks contain a very aromatic volatile oil and a resin.

In the holy anointing oil the proportions of these aromatics, as indicated by Moses (Ex. xxx. 22-38), are 500 *shekels* of myrrh, 250 of sweet cinnamon, 250 of sweet calamus, and 500 of cassia; to these were to be added 1 *hin* of olive oil. Although we here have the formula of this compound, the mode of making it is not described, and it is difficult to conceive how 1 *hin* of oil, which is about $9\frac{3}{4}$ pints, could hold in solution so much solid matter, the total weight of which, 1500 shekels, is equal to about 47 lbs. Such an amalgam would only produce a very thick paste, and the oil was evidently intended to be liquid, as it was not only ordered to be used for anointing the altars and utensils of the Tabernacle, but was commanded to be used for consecrating the High Priest, by pouring it on to his head in such abundance as to run down his beard and impregnate the skirts of his garments (Psalm cxxxiii. 2). Probably the odoriferous properties were in some way separated from the ligneous matter before mixing with the olive oil.

Several other aromatic substances used in the early ages have been the theme of modern investigation and dispute. The substances were sometimes made up in the form of ointments, which were lavishly used by the rich, not only in their toilet but also as a mark of distinction

bestowed on guests. Aromatics were likewise burned during their entertainments, and perfumes in a dry form were used to impart a sweet odour to their garments (perfumes which were probably necessary, as they did not eat with forks, and soap was yet undiscovered). Odoriferous substances were used for preserving the bodies of the dead; myrrh and aloes wood were in this mixture, which was very likely an unguent. The Spikenard ointment is said to have been of many ingredients; the word *nard* is derived from the Tamul word *nar*, which is used in India to designate many odoriferous substances, such as *nártum pillu*, Indian verveine; *nárum panei*, jasmine; *nárta manum*, wild orange, &c.

The "Nardinum" which was so very fashionable in Rome, both as an oil and as a pommade, was made from the blossoms of the Indian and Arabian nard-grass (according to Briker's opinion and researches). This would seem to refer to the *Andropogon laniger* above mentioned, and not to *Nardostachys Jatamansi*, as generally believed. The flowers of this latter are white and odourless, the rank perfume being only developed in the root.

As is the case generally in hot climates, oil was used by the Jews for anointing the body after the bath, and giving to the skin and hair a smooth and comely appearance before an entertainment (Ruth iii. 3, Prov. xxvii. 9, 16, Cant. i. 3, iv. 10). Strabo says the inhabitants of Mesopotamia use oil of sesame, also castor oil. At Egyptian entertainments it was usual for a slave to anoint the head of each guest as he took his place, castor oil being sometimes used; Egyptian paintings represent this custom. The Greek and Roman usage will be found mentioned frequently by Homer, Horace and Pliny. Athenæus speaks of the extravagance of Antiochus Epiphanes in the matter of ointments for guests (Wilkinson, "Ancient Egypt," 78).

Creech, in his annotations on Lucretius (Lib. IV. 1123), says: "Moreover they arrived at length to an excess of curiosity in regard to their ointments that was indeed wonderful; for Athenæus (Lib. XV. cap. II.) reports that 'they grew so nice as to require several sorts of ointments for one single unction, viz., Egyptian for the feet and thighs, Phœnician for the cheeks and breasts, Sisymbrian for the arms, Amaratine for the eye-brows and hair, and Serpylline for the neck and knees.'" But above all the rest, we may observe that the ancients made use of one sort of oil or ointment of great value and singular excellency; it was called *Oleum Susinum*, and made of lilies which in the Phrygian tongue were called σύσα, but chiefly of that sort of lily which the Greeks call χείνον, and to which it is believed allusion is made in Canticles v. 13, where the Church says of Christ, "His lips are like lilies."

Pliny describes the lily that is called χείνον to be of a ruddy colour (Nat. Hist., lib. XXI. cap. 5). Elsewhere, Pliny (Hist. Nat. XIII. 2) says, "*Oleum Susinum* was made of oil of Ben" (or Behen, a colourless, tasteless and inodorous oil expressed from the seeds of *Moringa pterosperma*, now naturalized in the West Indies—an oil which never becomes rancid and does not corrode steel, for which reason it is used in modern days by watchmakers as a lubricant), "roses, honey, saffron, cinnamon and myrrh." The amount of perfume used in the palmy days of Rome was enormous; the wealthy patricians were most prodigal in this respect. The perfumers were called *Unguentarii*, as they principally compounded unguents, and must have done an immense business. In Rome they congregated in a quarter called the "*Vicus Thurarius*." The most celebrated perfumer in the time of Martial was a certain individual named Cosmus, whom Martial frequently mentions.

At Capua there were such a number of perfumers, that the principal street of the city, named Séplasia, was almost entirely occupied by them. For the most part, these tradesmen were Greeks, and, as at Athens, their shops (taberna) were the rendezvous of the rich idlers of those days. The perfumed oils and ointments were made in great variety. The basis of the oils was generally the oil of Ben above-mentioned, and that of the unguents was a bleached and partly purified tallow. They were used not only for the hair, but to anoint all parts of the body, especially after the bath, which was quite a complicated process. It was also customary at banquets to honour the guests by pouring costly perfumed oils over their feet. Some of these were simple oils, such as *Rhodium*, made from roses; *Melinum*, made from quinces; *Metopium*, from bitter almonds; *Narcissimum*, from the narcissus. Perhaps the most fashionable oil after the *Oleum Susinum* above-mentioned was that called *Crocinum*, made from saffron (*Crocus*), which communicated both a fine colour and odour to the person; Heliogabalus never bathed without it. Butter is noticed by Pliny as used by the negroes and lower classes of Arabs for anointing their bodies. The natives of India prefer strong perfumes for this purpose, and use oil of santal and oil of patchouli. Savages also grease their bodies, but probably with the idea of being enabled to escape more easily from the grip of an enemy.

In the words of a classical writer on the manners and customs of the Romans, "The bath was a most important event in every-day life . . . Bodily health and cleanliness, although its original object, had long ceased being the only one; for the baths, decorated with prodigal magnificence and supplied with all the comforts and conveniences that a voluptuary could desire, had become places of amusement, whither people repaired for pastime and enjoyment."

Comparing the ruins of ancient baths with each other, and with the accounts of Vitruvius and Pliny, we find the essential parts of a Roman bath to be:—I. The *Spoliatorium*, a place where the clothes were left and consigned to *caprarii*, which were probably pegs, so called from their likeness to horns. II. The *Frigidarium* or cold bath room. III. The *Tepidarium* or tepid bath room. IV. The *Caldarium* or hot bath room, which was probably connected with the *Unctorium* or anointing room. The *Sudation* or sweating room was connected with the *Caldarium*. Those who desired to use the bath through all degrees of temperature, sought first to give their bodies the preparation which was considered necessary, by some sort of light gymnastics, ball-play and the like. The baths were always provided with rooms suitable for this purpose. Persons would then probably enter first the Tepidarium, in order not to be exposed suddenly to the heat of the Caldarium, where they were anointed with oil (Celsus I. 3), and it is probable that this was the place generally assigned to that operation, although we read of special *Unctoria*. The anointing with oil took place both before and after the bath; and even after they had already stepped into the bath, they sometimes left it again to be anointed a second time, after which they again betook themselves to the bath. The bathers took the oil with them to the bath (or rather the slave carried it) in phials of alabaster, gold and glass, as well as the *strigiles* or scrapers, and the *lintea*, linen cloths, to dry themselves. In the early days people were content with a simple pure oil, but at a later period costly salves as above described were the fashion. No doubt people anointed themselves at other times besides the bath, in order to reek of perfume the whole day through. (Geneca. Ephist. 86.)

Even the clothes were anointed with aromatic oils (Juv. III. and Martial VIII. 3, 10).

The luxury and magnificence of the Romans were manifested in the construction of their public baths more than in any other building; they were embellished with *chefs-d'œuvre* of sculpture and painting, and the floors were paved with slabs of marble and inlaid with mosaics. It is estimated that 870 baths were open every day to the public, and rich people possessed private baths of their own, which were even more sumptuous and extravagant in their method of conduction.

The Romans were not acquainted with the use of regular soap, but they employed an alkali, with which the greasy dirt was dissolved out of their clothes. This alkali, called *nitrum*, is referred to by Pliny XXXI. 10; but the cheapest solvent was urine, which was mostly used; the clothes were put in this, mixed with water, and then stamped upon with the feet; this process was performed by old people, whilst boys lifted the clothes out of the tubs. The white garments, after being washed, were subjected to the vapour of sulphur—being stretched on a frame, and the sulphur burned beneath.

Poor people in Rome cleansed their bodies with meal of lupins, called *lomentum*, which, with common meal, is still used in some places for that purpose.

Soap, as we understand the old English word *sope* (from the Greek *sapon* and the Latin *sapo*), was first introduced by the Gauls, who found out a way of making it from goats' tallow and the ashes of beech-wood. This was, no doubt, rather caustic, but it was uncontaminated with colouring matters and the deleterious perfumes put into common soaps of the present day. The soap was made into balls called "Pilæ Mattiaca," named after the town where it was manufactured—"*Mattiacum*" (modernized Marpurg). The French appellation of soap, "savon," seems to be due to a seaport town called Savona, near Genoa, where at a later period, most of the soap for the European market was manufactured.

The Romans, not content with swamping themselves with perfumes at their baths, their toilettes, and their banquets, loved to be surrounded in a perpetual atmosphere of scent, and used, as we use a handkerchief, to dry the perspiration from the forehead, a fine linen cloth called a *sudarium*, saturated with perfume.

THE FACE OF THE SKY FOR OCTOBER.

By Herbert Sadler, F.R.A.S.

SUN-SPOTS and faculæ are still increasing in number. The following are some conveniently observable minima of Algol-type variables (*cf.* "Face of the Sky" for September). Algol.—October 13th, 9h. 48m. p.m.; October 16th, 6h. 37m. p.m. U Ophiuchi.—October 2nd, 8h. 23m. p.m.; October 7th, 9h. 19m. p.m.; October 17th, 10h. 50m. p.m.

Mercury is a morning star during the first half of the month, and is very well situated for observation. He rises on the 1st at 4h. 19m. a.m., 1h. 43m. before the Sun, with a northern declination of 4° 47′, and an apparent diameter of $6\frac{1}{2}''$. On the 4th he rises at 4h. 28m. a.m., 1h. 39m. before the Sun, with a northern declination of 3° 15′, and an apparent diameter of $5\frac{3}{4}''$. About $\frac{74}{100}$ of his disc is then illuminated, and the planet is at its greatest brightness. On the 9th he rises at 4h. 54m. a.m., 1h. 21m. before the Sun, with a northern declination of 0° 2′, and an apparent diameter of $5\frac{1}{2}''$, about $\frac{88}{100}$ of the disc being illuminated. On the 14th he rises at 5h. 24m. a.m., or 1h. 0m. before the Sun, with a southern declination of 3° 35′, and an apparent diameter of 5″, about $\frac{94}{100}$ of the disc being illuminated. After that he rapidly approaches the Sun, coming into superior conjunction at 3h. a.m. on the 28th. He is in conjunction with Saturn at 7h. a.m. on the 3rd, being about 12′ south, the two planets, at 5h. a.m., presenting the appearance of a double star to the naked eye, Mercury, however, being markedly brighter than Saturn. This will be a very interesting spectacle, as Mars will be situated about 5° W.N.W. of the two planets, while Mercury and Saturn are about 3° N.W. of β Virginis. Mercury is at that time distant from the Earth about $99\frac{3}{4}$ millions of miles, Mars $237\frac{1}{2}$ millions of miles, and Saturn $963\frac{1}{2}$ millions of miles. While visible, Mercury pursues a direct path in Virgo, without approaching any very conspicuous star. Venus is invisible, and the same, for the purposes of the observer, may be said of Mars, as his apparent diameter, at the end of the month, does not exceed $4\frac{1}{4}''$.

Jupiter is still the conspicuous ornament of the evening sky. He sets on the 1st at 3h. 28m. a.m., with a southern declination of 9° 14′, and an apparent equatorial diameter of 48″. On the last day of the month he sets at 1h. 19m. a.m., with a southern declination of 9° 48′, and an apparent equatorial diameter of $44\frac{1}{2}''$. The following phenomena of the satellites occur before midnight, while Jupiter is more than 8° above and the Sun 8° below the horizon. On the 1st a transit egress of the first satellite at 7h. 31m., and of its shadow at 8h. 10m.; an occultation disappearance of the second satellite at 9h. 1m. On the 3rd a transit egress of the second satellite at 6h. 49m., and of its shadow at 8h. 11m. On the 5th an occultation disappearance of the third satellite at 7h. 3m. On the 6th a transit ingress of the fourth satellite at 11h. 44m. On the 7th an occultation disappearance of the first satellite at 9h. 50m. On the 8th a transit ingress of the first satellite at 6h. 59m., and of its shadow at 7h. 47m.; a transit egress of the satellite at 9h. 17m., and of its shadow at 10h. 5m.; an occultation disappearance of the second satellite at 11h. 19m. An eclipse reappearance of the first satellite at 7h. 22m. 12s. on the 9th. On the 10th a transit ingress of the second satellite at 6h. 17m., and of its shadow at 7h. 57m.; a transit egress of the same satellite at 9h. 9m., and of its shadow at 10h. 49m. On the 12th an occultation disappearance of the third satellite at 10h. 30m. On the 14th an occultation disappearance of the first satellite at 11h. 38m. On the 15th an eclipse reappearance of the fourth satellite at 5h. 58m. 52s.; a transit ingress of the first satellite at 8h. 46m., and of its shadow at 9h. 42m.; a transit egress of the same satellite at 11h. 4m., and of its shadow at midnight. On the 16th an occultation disappearance of the first satellite at 6h. 5m. p.m.; a transit egress of the shadow of the third satellite at 7h. 31m. p.m.; an eclipse reappearance of the first satellite at 9h. 17m. 43s. On the 17th a transit egress of the shadow of the first satellite at 6h. 29m.; a transit ingress of the second satellite at 8h. 39m., and of its shadow at 10h. 35m.; a transit egress of the second satellite at 11h. 32m. On the 19th an eclipse reappearance of the second satellite at 7h. 37m. 49s. On the 22nd a transit ingress of the first satellite at 10h. 34m., and of its shadow at 11h. 38m. On the 23rd a transit egress of the fourth satellite at 7h. 7m.; of a transit egress of the third satellite at 7h. 16m.; an occultation disappearance of the first satellite at 7h. 53m.; a transit ingress of the shadow of the third satellite at 8h. 10m.; an eclipse reappearance of the fourth satellite at 11h. 31m. On the 24th a transit ingress of the shadow of the first satellite at 6h. 6m., a transit egress of the satellite itself at 7h. 26m., and a transit ingress of the second

satellite at 11h. 3m. On the 25th an eclipse reappearance of the first satellite at 5h. 42m. 15s. On the 26th an eclipse reappearance of the second satellite at 10h. 14m. 18s. On the 30th a transit ingress of the third satellite at 7h. 27m.; an occultation disappearance of the first satellite at 9h. 43m.; a transit egress of the third satellite at 10h. 54m. On the 31st a transit ingress of the first satellite at 6h. 51m., and of its shadow at 8h. 2m.; a transit egress of the satellite at 9h. 10m., and an occultation disappearance of the fourth satellite at 9h. 20m. During the month Jupiter describes a very short retrograde path in Aquarius, but without approaching any naked-eye star.

Saturn does not rise before midnight, and Uranus is in conjunction with the Sun on the 25th. We defer an ephemeris of Neptune till November.

October is rather a favourable month for observations of shooting stars, the most marked shower being that of the Orionids, from the 17th to the 20th of the month, the radiant point of which is situated in 7h. 0m. R.A. and + 15° declination. The radiant point rises at the date named at about 8h. 45m. p.m., and sets shortly after 4 a.m.

The Moon is new at 0h. 58m. a.m. on the 3rd; enters her first quarter at 10h. 57m. p.m. on the 10th; is full at 1h. 45m. p.m. on the 17th; and enters her last quarter at 1h. 56m. p.m. on the 24th. She is in apogee at 9·8h. p.m. on the 1st (distance from the earth 252,600 miles), in perigee at 5·4h. p.m. on the 16th (distance from the earth 222,510 miles), and in apogee again at 4·7h. a.m. on the 29th (distance from the earth 252,300 miles). Her greatest eastern libration is at 2h. 16m. p.m. on the 10th, and her greatest western at 2h. 34m. p.m. on the 22nd.

Chess Column.

By C. D. Locock, B.A.Oxon.

Special Notice to Correspondents.—Till further notice, communications for this column should be addressed "Chess Editor, *Knowledge Office, 326, High Holborn, W.C.*"

Solution of Problem No. 3 (*by C. D. L.*): 1. Kt to B6, and mate's next move.

Correct Solutions from :—Alpha, K, T. E. Kerrigan, J. Landau, W. T. Hurley, M. B. (Jesmond), H. S. Brandretti, Giu. Pianissimo, T. A. Earl, C. T. Blanshard, R. W. Houghton, W. E. B., F. R., E. B., White Knight, R. T. M., C. S., G. F., J. G. Ellis, A. J. Luisham, Betula, A. Rutherford, T., and J. Taylor—(23 all correct).

Alpha.—After 1. . . QQ5, 2. KtB3 is not mate. You also curiously give 2. QB5 in reply to 1. . . QK5. There is another variation, 1. . . QB7, 2. KtQ3.

W. T. Hurley.—Duals following purposeless defences are no defect. In the present case, considering the freedom of the Black Queen, it seems surprising that there are not more.

T. A. Earl.—Positions may be diagrammed by means of either (1) rubber stamps and coloured inks, or (2) coloured pencils, or (3) circles round letters representing black pieces, *e.g.*, (P)=Black Pawn.

Giu. Pianissimo.—Certainly it is easy: but no two-movers are difficult.

White Knight.—As this column goes to press on the 12th of each month, extension of time is an impossibility. Reply to you last month was sent with proofs.

T. H. Billington.—You did not merely claim "no solution." You *assumed* the mistake, and sent in a solution, by which you had to be judged.

Betula.—The Bishop variations are not new, but they are certainly no defect, except for the fact that they have no connection with the key-move. The duals with the Knight are also harmless.

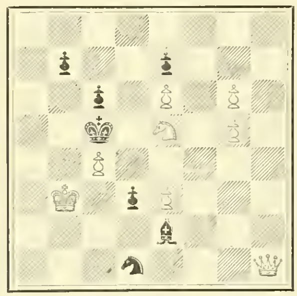
A. J. Luisham.—Every competitor had three courses open—(1) Simply to claim "no solution," (2) To write for information, (3) To take for granted the very obvious misprint, and send solution accordingly. Merely ignoring the problem is not sufficient.

C. T. B.—*Apropos* of "Chess on the brain," did you notice that your three-mover (No. 42) in the *Liverpool Mercury* is a rudimentary picture of your initials?

PROBLEM (No. 4).

(From a Foreign Paper.)

Black.



White.

White to play, and mate in three moves.

Special Notice.—Solvers are particularly requested (1) To read the notice at the head of this page; (2) To send, in addition to White's second moves, the moves of Black which compel them.

Leading Solvers' Scores.

Alpha	14	M. B. (Jesmond)	14
W. E. B.	14	C. T. Blanshard	14
T. E. Kerrigan	14	R. T. M.	14
W. T. Hurley	14	J. Landau	14
K.	14	A. Rutherford	14
Giu. Pianissimo	14	T.	14
T. A. Earl	14	J. Taylor	14
F. R.	14	Betula	10
R. W. Houghton	14	A. C. L. Wilkinson	9
G. F.	14	A. J. Luisham	6
E. B.	14	J. G. Ellis	6
C. S.	14	White Knight	6

Game at odds of Pawn and two moves. (Played at Liverpool last August.)

Remove Black's KBP.

White (G. F.)	Black (J. E. P.)
1. P to K4	1. . . . . .
2. P to Q4	2. QKt to B3 (*a*)
3. B to Q3	3. P to K4 (*b*)
4. P to Q5	4. QKt to K2
5. P to KB4	5. P to Q3 (*c*)
6. P × P	6. P × P
7. KKt to B3	7. B to Kt5 (*d*)
8. Castles	8. Q to Q3
9. B to K3!	9. P to QR3 (*e*)
10. Q to K2 (*f*)	10. KKt to B3
11. Kt to B3 (*g*)	11. P to KKt3 (*h*)

12. QR to Qsq (*i*)	12. B to Kt2
13. P to QR3 (*j*)	13. Castles (KR)
14. P to QKt4 (*k*)	14. Kt to Ksq (*l*)
15. P to R3 (*m*)	15. B × Kt
16. R × B	16. R × R
17. Q × R	17. Q to KB3
18. Q to Kt3 (*n*)	18. Kt to Bsq
19. B to KKt5 (*o*)	19. Q to Q3
20. R to KBsq	20. Q to Q2 (*p*)
21. P to Q6 (*q*)	21. Q × P (*r*)
22. Kt to Q5	22. P to B3 (*s*)
23. Q to B3	23. Q to Q2 (*t*)
24. B to B4 !	24. P × Kt (*u*)
25. B × Pch	25. K to Rsq

White mates in three moves.

Notes.

(*a*) Not so good as P to Q3. For White should now continue with 3. P to Q5, Kt to K4 ; 4. P to KB4.

(*b*) Kt × P would obviously lose a piece ; but the best defence again is P to Q3, for the Knight could now capture the Bishop if attacked twice by the Pawns.

(*c*) Forced now ; for if Kt to Kt3, White simply changes Pawns and checks with the Queen, followed by P to K5.

(*d*) Obviously preparing to Castle on the Queen's side,—a plan which he never carries out. Kt to Kt3 seems preferable.

(*e*) He dare not Castle on account of 10. B × P, P to QKt3 ; 11. B to R6ch, K to Q2 ; 12. Kt × P, Q × Kt ; 13. Q × Bch, K to Ksq ; 14. B × P ! and wins.

(*f*) So far White has played excellently, and has in fact a winning position. But now he begins to indulge in a series of weak moves which partly justify the odds received. QKt to Q2 would at once increase his advantage.

(*g*) Again, QKt to Q2 would be much better.

(*h*) Black now prepares Castling on the other side ; perhaps he would do so better by Kt to Kt3 and B to K2.

(*i*) Owing to the weak position of his Queen's Knight, White gains nothing by 12. Q to B2, B × Kt ! (if 12. . . . B to Kt2 ; 13. Kt × P, Q × Kt ; 14. B to Q4) ; nor by 12, P to KR3, B × Kt ! (if 12. . . . B to Q2 ? ; 13. Q to B2 ! threatening both B to B5 and Kt × P). He might play 12. Kt to Qsq.

(*j*) Now perhaps 13. Kt to Ktsq is the most promising course, with a view to Kt to Q2 or P to QB4.

(*k*) This greatly weakens the Queen's side, and leaves the Knight undefended. Again, Kt to Ktsq seems best.

(*l*) Kt to R4 seems much better, and would render the subsequent slaughter unnecessary.

(*m*) A wasted move. Kt to Ktsq with a view to P to QB4 is still best.

(*n*) Q to Kt4 is probably better. Q × Q is also good enough.

(*o*) R to KBsq should be played at any rate first.

(*p*) If White's reply is sound he should play something to KB3 instead.

(*q*) Ingenious, if not quite sound. The safest course was Kt to Qsq and Kt to K3.

(*r*) Kt (from Ksq) × P was also feasible. If then 22. Kt to Q5, P to B3 ; 23. Kt to B6ch, B × Kt ; 24. B × B, Kt to B2 (if Kt × P ? 25. B to B4ch), and Black has good chances of drawing.

(*s*) He had still a good resource in Kt to Kt3.

(*t*) Q to Bsq. is the only defence. White then recovers the Pawn by exchanging and checking with the Knight.

(*u*) Fatal. But if K to Rsq ; 25. Kt to Kt6 wins, as "G. F." points out. The ending is very well played by White.

KNIGHTS AND BISHOPS.

(*Concluded from p.* 180.)

9. There is one other advantage of the Bishop, incidentally mentioned under Point 4, which deserves a separate heading. This is the power of advancing or retreating, when attacked, *without being diverted from its purpose*. When a Knight is compelled to move, its range of attack is entirely altered.

To sum up the results of this not very scientific investigation, it appears that the Bishop has the advantage in six points out of the nine. Curiously enough no less than three out of these six points are applicable only, or, at any rate, specially, to the end-game—the very stage in which the Knight is supposed to assert its superiority. It is necessary to assume, therefore, that in the end-game, Point 2 is so important as to outweigh Points 5, 6, and 7. And this may well be the case. Winning Pawns is the essential point in an end-game, and in this the Knight's superiority is unquestioned.

Taking only the opening and middle game into consideration (and omitting, therefore, points 5 and 6), the Bishop has the best of four points out of the remaining seven ; a result in accordance with its generally estimated value. This, of course, is only a coincidence ; a merely numerical statement of advantages does not amount to proof. [Notice that Point 7 is not omitted. Though a Bishop can only *totally* confine a Knight in the end-game, a *partial* confinement is of constant occurrence early in the game. For instance, a Bishop at K3 may be said to partially confine a Knight at K3. It guards four squares attacked by the Knight, and though the Knight also guards four squares attacked by the Bishop, the Bishop can move *beyond* the Knight's range, past the guarded squares]. The combinations of minor pieces must be briefly dismissed. Two Bishops are stronger than Bishop and Knight, which, again, are superior to two Knights. Two Bishops can mate easily, Bishop and Knight with difficulty, two Knights not at all. Two Bishops can also prevent a King from crossing the board, even more effectually than a Rook. When placed side by side the King cannot even approach them.

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CONTENTS.

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EARWIGS.—II.

By E. A. Butler.

(*Continued from page* 183.)

THE partiality of Earwigs for flowers, and particularly for dahlias, has led to the adoption of various devices in gardens to get rid of them, advantage being taken of their fondness for dark corners. Mouffet, an old writer to whom we have referred before, speaks of "ox-hoofs, hogs'-hoofs, or old cast things" as being set up in his time on sticks as traps by the country women, to whom Earwigs, or erriwiggles, as they call them, are exceedingly hateful, as he says, "because of the clove gilliflowers that they eat and spoyl." Crabs' and lobsters' claws have been used with effect in a similar manner. Into the recesses of these the Earwigs delight to penetrate in the daytime, just as they have learnt to do into the spurs of the tropæolum flowers (Fig. 4) since

Fig. 4.—Tropæolum flower, with Earwig in spur. Part of the flower has been removed, to disclose the Earwig.

these were introduced into British gardens. But the creatures are so ubiquitous, so abundant, at least in this country, and so determined to skulk out of sight in the daytime, squeezing themselves into most out-of-the-way places, under stones, tiles, bark, leaves, or garden rubbish of any kind, wherever there are but a few cubic millimetres of breathing space, that it is next to impossible to devise means which shall be very effectual in reducing their numbers. Not only do they damage flowers, but like wasps, they are destructive to ripe fruit as well; De Geer fed some of those he kept with chopped apples, which they eagerly devoured. Windfalls from the fruit trees in orchards are soon found out and excavated by Earwigs, which in the daytime curl themselves up in the hollows they have made in the fruit, sticking close to their booty, ready to fall to again as soon as the promptings of hunger and the return of darkness combine to render a banquet desirable and safe. Though, as a rule, vegetarian in diet, yet they have no objection to eating animal food if opportunity serves, and as we have already seen, may even, when hard pressed, resort to cannibalism; but experiments seem to indicate that they will be prepared to suffer great extremities before falling back on such a practice. They may be kept for a long time in numbers together, without showing any disposition to attack one another, even if the supply of food be scanty. They are not often found indoors, but if accidentally introduced, may sometimes do irretrievable damage. The entomologist especially has to be on his guard against them; if they do manage to gain access to his setting boards, they have no hesitation in trying their jaws upon the insects that may be stretched on them. The antennæ of dried insects, particularly of certain special kinds, seem to be peculiarly delicate morsels. The little booklouse, when attacking insects mounted on card, usually makes for the antennæ first; and the Earwig seems to have a similar taste. One collector records that a single Earwig passed along his boards, and in two days removed the antennæ from thirty-six moths all belonging to one species, while examples of other species were left untouched. The entomologist who hunts for moths at night by smearing the syrupy liquid, technically called "sugar," on the trunks of trees as a bait, often finds, on revisiting his trap, that crowds of Earwigs have found out the store, and are revelling in the tempting sweets.

Hitherto we have spoken only of the Common Earwig

(*Forficula auricularia*). A word or two may now be said about the remaining British members of the family. The only other that is at all common is that called the Little Earwig (*Labia minor*), (Fig. 5), a much smaller insect, easily distinguished by that feature alone. It is a flat little thing, hardly more than a quarter of an inch long, forceps and all, of a yellowish-brown colour, with darker head and antennæ, and pale straw-coloured sprawling legs. For some reason not very easy to discover, it manages to do with only ten or twelve joints to its antennæ, instead of the fifteen of the larger species, and the last two of these are, equally inexplicably, of a pale yellow colour, the rest being deep brown. The forceps of the male differ greatly from those of the larger species, and are much less elegant. At the point where they join the body they are widely separated from one another, instead of being nearly contiguous; they are only slightly curved, and have no teeth on the inner edge. The forceps of the female, on the other hand, are very similar to those possessed by the same sex in *Forficula auricularia*. This little insect is not nearly so retiring in its habits as its larger relative. Its wings are rather larger in proportion to its body, and it is much more ready to use them. It may be found flying, even in the daytime, about gardens and dunghills, and so little fears the neighbourhood of man that it is sometimes met with in busy streets, flying, or running about on the pavement at the imminent risk of its life from the feet of passers-by. About midsummer is the best time to find the Little Earwig; it is not nearly so plentiful as the larger species, though fairly common, and it probably does but little damage.

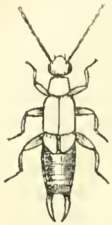

Fig. 5.—Little Earwig (*Labia minor*), male. Magnified four diameters.

In great contrast to this little creature is the Giant Earwig (*Labidura riparia*), which is as rare as either of the other two is common. It is a fine large insect, over an inch long, of a reddish-yellow colour. Its size alone is sufficient to distinguish it from almost all our other species. It was first recorded as a British insect in 1808, when the Rev. W. Bingley found it in some numbers near Christchurch, Hants. This seems to have been its head-quarters, but it spread east and west from this locality, and the places at which it has since been captured range along the south coast from Dorsetshire to Kent. The last recorded specimen was taken five years ago on the coast of Dorsetshire. As the insect seems to have been plentiful when first discovered, it is possible that it may still be existing in greater numbers than the records of its capture would lead us to infer; and those who live in the region of its former metropolis should keep a sharp look-out, especially near high-water mark and towards evening, when they may perhaps gain an introduction to stray individuals of this fine species, as they come out for their nightly foraging. The forceps of the male have a large tooth on their inner side like those of the Common Earwig, but it is situated nearer the tip.

Besides this rare southerner, there is also a still rarer northerner, *Anisolabis maritima* by name, which was found at South Shields in 1856, by that indefatigable entomologist, Mr. T. J. Bold. As it was discovered so near a port and had not been met with elsewhere, Mr. Bold thought that it had been introduced by shipping; but as he found a young one in the autumn, it would seem that the species had begun to make itself at home by establishing a nursery, and had settled down, at least for a time. It is rather larger than the Common Earwig and differs also in colour, being dark blackish-brown above and yellowish beneath. But its most striking point of difference is the entire absence of wing-covers and wings, a peculiarity which makes it look like an overgrown larva. The forceps of the male are remarkable in being unequally curved, whereby they acquire an aspect of deformity; the right branch is more curved than the left. Whether this insect has permanently established itself on British soil and is still to be met with in the neighbourhood of its first appearance, or whether it has found the climate uncongenial, or the accommodation unsuitable, and has therefore yielded to the force of circumstances and become extinct, so far as our own country is concerned, is not definitely known. Here then is an opportunity for our north country friends to distinguish themselves by the re-discovery of the wingless Earwig of South Shields.

The next species is *Forficula pubescens*, a yellowish-brown insect, smaller than its close ally, the Common Earwig. Scarcely anything is yet known of the distribution of this insect in Britain, and as there are very few people who take the trouble to record the doings of such despised things as Earwigs, it may be long before more definite information is obtained. It is a south European species, but it has been recorded from some places on the Dorsetshire coast, and might very likely turn up in other localities as well, if only properly looked for. It is in an intermediate condition between the last-mentioned insect and the Common Earwig, having wing-covers indeed, but scarcely anything worth calling wings for them to cover; and thus we see that though the number of British Earwigs is so small, they are, nevertheless, an exceedingly interesting collection, since they represent the chief variations of form we might expect to find in a single family of insects.

Our sixth and last species is another pale and rare one called *Chelidura albipennis*. Here again we have a wingless Earwig; its wing-covers are perfectly formed, but they protect no wings, and consequently the insect cannot fly. It is very variable in size, sometimes only slightly longer than the Little Earwig, at others much bigger; its body and forceps are both hairy. It is widely distributed on the Continent, and in England has been caught by Professor Westwood at Ashford. As these various species of wingless Earwigs have in all cases perfectly developed forceps, it seems pretty plain that whatever aid these instruments may sometimes render in the manipulation of the wings, such a function can neither be the only, nor indeed the chief use of them, else they would in the apterous forms have followed the wings into a state of abortion. Nor can we imagine a sensory use for them, such as was suggested for the two pointed styles of the house cricket, and possibly for the two spindle-shaped organs similarly situated in the cockroach: the Earwig's forceps are too hard for anything of this kind, and we are thrown back, therefore, on the hypothesis that their chief function is that of an offensive and defensive armature.

Notwithstanding their retiring habits, Earwigs do not escape from the attacks of parasites. Westwood states that there is a kind of ichneumon fly which attacks the Common Earwig, depositing eggs in its body, the contents of which are devoured by the larvæ hatched from them; and I have myself found a large fleshy maggot, apparently that of a flesh-eating Dipterous fly, inside the body of a full-grown Earwig. Internal insect parasites such as these, whether Hymenopterous, like the ichneumon fly, or Dipterous, like the maggot above referred to, when attacking insects which pass through a complete metamorphosis, usually become mature while their host is in the

chrysalis condition, and thus the latter does not itself reach maturity, but perishes while still a chrysalis, through the development and exit of the parasite. Here the very fact of the host's being in a quiescent condition, and taking no food, is the means of sounding its own death knell, the parasite absorbing its vital tissues while it has no power of repair; the parasite is complete master of the situation, and, in consequence, it is the rarest thing imaginable for the host to struggle on to maturity. But with such an insect as the Earwig the case is different. Here we have an insect which has no quiescent pupa stage, but continues to take food throughout life, thereby to some extent perpetually neutralizing the effect of the parasite's attacks; and it is hardly surprising, therefore, that in such a case the maturation of the parasite should be delayed till much later in the life of the host, and that the latter should thus be able to reach maturity in safety. As a factor in the perpetuation of its race, however, it would probably be just as devoid of influence as if it had died in pupahood, as the parasite would probably subsist at the expense of its reproductive organs, and thus render it barren. The exit of the parasite, under such circumstances, would be an interesting event to witness, and one would be glad to know the precise point at which it escapes, as well as the means by which it bursts through, for the skin of the perfect Earwig is much harder and tougher than it is during the larval and pupal stages, and the parasite is therefore much more effectually imprisoned. Besides these insect parasites, a *Filaria*, or thread-worm, has been discovered infesting the Common Earwig, as well as a *Gregarina*, a creature of much simpler organization even than the thread-worm.

The systematic position of Earwigs has been a matter of considerable controversy; they constitute a very compact family—the *Forficulidæ*—and were placed by Linné in the order Coleoptera, or beetles. In some respects they certainly do exhibit a tolerably close resemblance to one particular group of this order, viz. the rove-beetles, a set of carrion and dung-feeders which are technically called Brachelytra. These are beetles of narrow elongate body, with very short wing-covers, so that the greater part of the abdomen is exposed, instead of being, as is generally the case, concealed beneath the overarching elytra, or wing-covers. It was this small size of the flying apparatus which suggested the name of the group, Brachelytra being Greek for "short elytra." Some of the larger species of this group (Fig. 6) are about the size of Earwigs, and in consequence of their elongate form and short elytra are very generally mistaken for them, the resemblance being sometimes heightened by the presence of short, pointed, projecting organs at the end of the body in the position of the true Earwig's forceps. But the resemblance is after all only a superficial one. No true projecting *forceps* are ever developed in the rove-beetles; their wings are differently veined and differently folded from those of Earwigs, and lastly, and most important of all, the life-histories of the two groups are utterly unlike, for the rove-beetles pass into a quiescent chrysalis stage before becoming perfect insects, which is never the case with Earwigs. By later systematists the Earwigs were removed from the Coleoptera and put into the Orthoptera, amongst the cockroaches, crickets, grasshoppers, and locusts, forming, however, a distinct section of the order. In the nature of their mouth organs and the style of their metamorphosis they do indeed resemble these insects, yet they are so peculiar, in the matter of the wings, that their location with the Orthoptera did not satisfy all naturalists; consequently Kirby in 1823 removed them and made them into a separate order by themselves, under the name Dermaptera, an unfortunate piece of nomenclature, since this term had previously been adopted as the name of the whole order which is now called Orthoptera. Westwood therefore proposed to replace the name Dermaptera by Euplexoptera (well-folded wings), in allusion to the complicated system of wing-folding which distinguishes Earwigs; but the pendulum has again swung round in the opposite direction, and they are now again grouped, at least by professed entomologists, in the order Orthoptera.

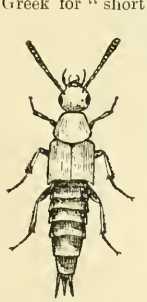

FIG. 6. *Philonthus æneus*, a Rove-Beetle, sometimes mistaken for an Earwig. Magnified three diameters.

We may conclude with a brief reference to the peculiarities of the popular names of these well-known pests. It is remarkable that in almost all the languages of Europe they are known by names which have some connection with the word "ear." It is always the ear "worm," "borer," "piercer," "twister," or something of that sort, names which obviously reflect the vulgar and wide-spread superstition that the Earwig creeps into the human ear and causes death by effecting thence an entrance into the brain. It is curious that so manifestly absurd an idea should ever have gained such wide credence—so wide indeed as to have been incorporated into the traditional lore of all the most civilized nations of the world—and still more so that it should even yet show strong signs of vitality. Such a notion of course explains the popular prejudice against the Earwig, which indeed is not an insect that has ever succeeded in inspiring either admiration or respect; on the other hand, superstitious fear, hatred, or contempt have generally been the feelings with which it has been regarded, and even its name was once used as a scornful epithet, a synonym for an "inquisitive informer"—no doubt in allusion to its habit of poking its head into corners.

THE MUSHROOM.

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DURING the months of September and October, especially if the air be moist and warm, inviting-looking patches of white-capped Mushrooms spring up in the green grass fields. Some are small like round white buttons; others are large and have the appearance of a plate supported on a stalk. These larger ones are much darker in colour than their diminutive neighbours. They grow with great rapidity. I have gathered Mushrooms one morning, leaving the ground destitute of a vestige of them, and two mornings afterwards an abundant crop has presented itself on the same spot.

The common Mushroom is a member of a very large genus—the genus *Agaricus*. It consists of some hundreds of species, and has been broken up into a number of sub-genera, and to one of these, *Psalliota*, the common Mushroom belongs. Its botanical name is *Agaricus* (*Psalliota*) *campestris*.

The stalk, technically called the *stipe*, which is so evident in older specimens, is cylindrical in shape, and in colour generally white. The disc which it supports is termed the *pileus*. Its colour is variable, whitish and flaky on its upper surface, as a rule, but at times brown and scaly. Alteration of situation affects it in this way, as is the case with many other plants.

On the under surface of the cap are a number of gills of a brown colour, disposed in a radial fashion. They are not all of the same size, some running from the stalk to the periphery, while others stop at intermediate places on the way, but they are all disposed so that the inter-spaces between the adjacent gills are kept of the same breadth. Half-way up the stalk of the older specimens, which we are supposed to be examining, there is a collar formed of a flaky material which has the appearance of having been torn from some other body in the course of its growth. It is called the *velum* or veil. A glance at a series of specimens, ranging in age from the button stage upwards, reveals the origin of the veil. In the youngest, the gills are not visible, the cap is nearly spherical and its margin lies near the upper portion of the stalk (Fig. I., 3). The existence of a cavity formed by the cap and the stalk is obscured by a membrane joining the periphery of the cap and the stalk. An older form shows that a tearing of this tissue is taking place consequent on the expansion of the cap, and the line of rupture is near the circumference of the cap. As the cap increases, the membrane is completely separated from it and is left as a frayed ring on the upper part of the stalk.

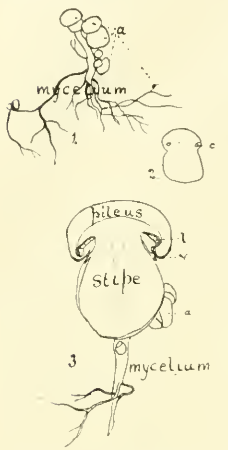


FIG. I. 1. Mycelium (spawn) of Mushroom carefully washed. Young fructifications (Mushroom plants), *a*, are seen arising on it. 2. Young Mushroom cut vertically through the centre, showing the cavities, *c*, into which the gills will afterwards grow. 3. Longitudinal radial section of young Mushroom at a later stage than 2; *l*, gills; *v*, velum or veil; *a*, younger Mushrooms.

The gills in the younger specimens are often of a delicate pink hue, while in others they are whitish. In fact, we are dealing with a very variable species, which is common in rich pastures, according to Berkeley, in most parts of the world.

The base of the stalk is connected with a number of white threads. If we carefully remove the earthy and other particles from these we shall find that other stalks are connected to them, so that we have a large number of Mushrooms all united together by these strands. Made up in dry patches of manure, the threads or strands are sold in shops under the familiar name of Mushroom spawn. They ramify through the soil wherever these forms grow. In all probability, then, there is some vital connection between the Mushroom spawn and the Mushroom plant.

If the cap of a Mushroom, just arrived at maturity, be placed in its natural position on a sheet of paper and allowed to remain there for some time in a still atmosphere, it will be found, on removing it, to have left an impression of its gill system on the paper, by the deposition of minute dust-like particles, which naturally suggest to one's mind their connection with the gills themselves. They are so minute that a hand lens is useless for their examination, so we select a portion of the cap and place it in a slit in a piece of pith, and with a razor wetted in dilute alcohol we cut an extremely thin tangential vertical section. Under a lens the section appears as represented in Fig. II., 1.; under a low power of the microscope, a single lamella has the appearance of Fig. II., 2. In the centre is a lax tissue composed of elongated cells, and called the *trama*. It is bordered on both sides by smaller cells which form the *sub-hymenial layer*. Surrounding this layer is a belt of larger cells, the *hymenial layer*. On some of these may be noticed two minute stalks bearing, each one, a small oval body. This will be better observed on reference to Fig. II., 3, which is a small portion of the lamella very much magnified. The oval bodies are called *spores*. They are of a brownish-purple hue. The stalks on which they arise are termed *sterigmata*, and the cell which bears sterigmata is called a *basidium*. Between the basidia are cells which do not bear spores, but appear to act as padding. They are known as *paraphyses*.

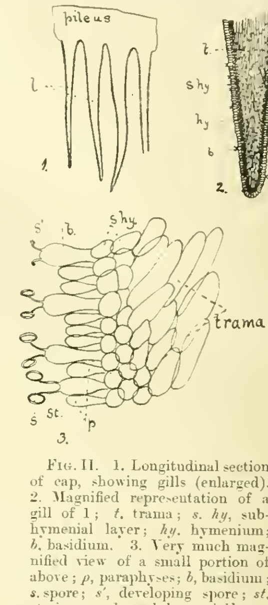


FIG. II. 1. Longitudinal section of cap, showing gills (enlarged). 2. Magnified representation of a gill of 1; *t*, trama; *s. hy*, sub-hymenial layer; *hy*, hymenium; *b*, basidium. 3. Very much magnified view of a small portion of above; *p*, paraphyses; *b*, basidium; *s*, spore; *s'*, developing spore; *st*, sterigma; *s. hy*, sub-hymenial layer.

The spores of *Agaricus campestris* and of the *Hymenomycetes* (the division of Fungi to which it belongs) generally are comparable, according to some, to the gonidia of the potato-disease fungus, that is, they have been formed asexually. According to others they are true spores, but as male and female organs have never been found in this plant, apogamy (or suppression of the union of male and female elements) is supposed to have taken place. For the sake of convenience we call them spores, and the Mushroom plant on which they arise, the *sporophore*.

From the spores the Mushroom plant arises. It is curious, however, that the germination of these, in the particular species with which we are now dealing, has never been observed, although it has been seen in allied forms. In these cases there were many failures before good results were obtained, these being due to conditions of temperature and moisture, &c., so that far from destroying our hopes in this case, we may look soon for an account of observations on the germination of the spores of *Agaricus campestris*.

Nevertheless, at the present time curious speculations have arisen anent these spores, and the botanist's inability to germinate the spores has given an air of truth to them rather than otherwise. Mr. Straton, writing in *Nature*, of 16th November, 1890, states: "The common Mushroom (*Psalliota campestris*) is particularly agreeable to sheep and oxen, and is abundant in autumn in rich pastures. Although there is still much in our knowledge of its life-history that is incomplete, yet it is evidently composed of two main periods: first, a parasitic period passed in the body of an animal host; and secondly, a saprophytic period passed on some suitable organic soil. Let us sow the

spores of a ripe Mushroom as carefully as we may, none of them will grow; the first stage of the Mushroom's existence must be passed in the body of an animal host, and as horses, sheep, and oxen are all readily attracted by its taste and mealy smell, it has never any difficulty in finding a host to take it in." Mr. Straton here takes it for granted that the spores must pass through the body of an animal such as the horse before germination will take place, and he consequently adduces the pleasant smell and taste of the Mushroom as attractive characters of value to the plant. But has a short residence within an animal host been proved to be a necessary probation to germination? I think not. It may or may not be the case, however. The question is an interesting one, and my remarks may, perhaps, elicit further information on this point. Mr. M. C. Cooke, in an article on the "Attractive Characters of Fungi,"* does not evidently give unqualified assent to the opinion expressed by the writer just quoted. He states: "Whether horses, oxen and sheep really *eat* the common Mushroom we venture to call in question, but they *do* eat the grass upon which the fungus spores have fallen." We have observed horses, cattle and sheep eating the grass all around where Mushrooms have been growing, and seen them pass on, leaving the Mushrooms for us to gather on our own account. This does not show much animal predilection for fungus food, and hardly bears out the paragraph that "horses, sheep and oxen are readily attracted by the taste and mealy smell." Without venturing to throw doubt upon the old faith that the spores of the Mushroom are destined to pass through the entrails of a horse, or that a horse or cow may sometimes even eat a Mushroom if it comes in its way, still we have great hesitation in accepting as an article of belief that they seek them out and devour them bodily, for the sake of the preservation of the species." Another writer maintains that insects, such as flies and beetles, whose larvæ are often met with in decomposing Mushrooms, are the active agents as much as horses and oxen in developing the spores. He believes that a sustained temperature may be necessary for their development, and this they find in the bodies of these animals. Does this not seem nearer the mark, than the statement that during a period of its existence the Mushroom is a parasite —that is, it feeds on the tissues or juices of a living host?

The product of the germinated spore consists of a number of fine threads, or hyphæ, which unite to form the spawn, or mycelium. The mycelial strands may sometimes attain the thickness of thin whipcord. They are produced by a weaving together of the hyphal filaments. Here and there small knobs appear on them, which develop gradually into the Mushroom. The tissue of these is at first continuous, but soon disintegration takes place, resulting in the formation of an annular cavity dividing the circumferential portion of the cap from the stalk. (Fig. I., 2, *c*.) Into this cavity down-growths of the cap make their appearance and form the gills. The tissue of the gills is a further development of that of the cap. The ends of the filaments which border the gills are, as may be seen on reference to Fig. II., at right angles to that of the trama. In the trama the filaments are not closely woven together; while in the sub-hymenial layer they are so closely wefted that it appears as made up of small closely compacted cells. Outside the sub-hymenial layer the extremities of the filaments form the basidia and paraphyses. From the ends of the basidia the stalks, or sterigmata, arise. A swelling sooner or later appears at the apex of each sterigma, and this enlarges into a spore, which, because it is produced on a basidium,† is called a basidiospore. The spores contain the greater part of the protoplasm of the basidia. They soon acquire a thick coat, and their connection with their parent becomes less and less until at last they drop off as the purplish-brown bodies of which we previously spoke. The life-history diagrammatically represented would be as follows:—

basidium ↘ basidiospores ↙ mycelium (spawn) ↖ sporocarp (Mushroom plant) (apogamy) ↗ basidium

The whole mass of the Mushroom is made up of the wefted threads of enormously long and branched filaments, which have been produced presumably from a single spore. We have no evidence, however, against the assumption that the mycelium on which a Mushroom arises has arisen from more than one spore. The Mushroom has all its parts developed some time before it is seen above ground. Its unexpected appearance there is doubtless consequent on an increase in the size of its cells, and not on the formation of new cells. "In *Agaricus vulgaris*," De Bary says, "I succeeded in determining, by measurement of the cells and counting their number on the transverse section, that the increase in length and breadth of the stipe, which becomes, on an average, 50—60 mm. long, from the time when its length was about 3 mm., and its cells could be exactly measured, must be almost exclusively due to an extension of the cells."‡

During the primary stages of its growth, the cells on the upper surface of the cap grow more rapidly than those on the lower. The secondary period is marked by a more rapid growth in the opposite direction, so that the margin of the cap is brought further and further from the stalk.

From what has been already indicated we can see that the tissue of the Mushroom is not a true tissue, but such as appertains to the lowest forms of plants—the Fungi. The Mushroom, then, is a fungus. Its mode of life is typical of that seen in the majority of the members of that group. In its cells there is no green colouring matter (chlorophyll), and in consequence it is unable to make use of the carbon dioxide of the air as its source of carbon. It relies upon other sources for it, finding it in the decaying vegetable matter of the manure of sheep, horses, oxen, &c. It assimilates the already elaborated carbonaceous materials by the action of a ferment secreted at the tips of the fibrils of its mycelium, and also takes up mineral matters from the soil.

The mycelium or spawn exists apparently for years below ground, that is to say, it is perennial, while the fructifications—the conspicuous Mushroom plants—are transitory structures; but as no one has observed the germination of a spore, we are unable to say what time must elapse between that act and the production of a Mushroom plant. It is the spawn which absorbs the nutrient material. Its effect upon its surroundings is sometimes seen in the production of "fairy rings," although these are not so commonly formed by this species as by some of its allies. The miraculous origin of these rings has now been exploded; poets must be content with a less imaginative, although at the same time more

* *Nature*, 20th November, 1890.

† A cell, from the end of which a spore is produced in the manner indicated, is called a basidium.

‡ De Bary, "Comparative Morphology and Biology of the Fungi, Mycetozoa, and Bacteria," page 55.

satisfactory, interpretation of their appearance. Many fungi of the Mushroom tribe show a tendency to spread in all directions from the spot where their mycelium has first obtained its hold on the soil. They exhaust the soil, so that the grass does not grow well there, but as they spread further out, the place on which they formerly stood produces a luxuriant crop of grass, on account of the extra supply of nutritious matter formed by the decay of their bodies. Thus poor and then good grass follow one another on the same zone of soil.

Agaricus campestris is of use to men, but a few of its allies are the dread of the forester, and others are deadly poisonous. It may be remarked in passing, however, that the majority of the cap-fungi are not poisonous, and that more use should be made of the large number of edible fungi which we have in this country. Of these the Mushroom is the only one under cultivation. Mushroom beds are well known to gardeners, and it is not an uncommon thing now-a-days to find a range of darkened houses specially devoted to their culture. A curious use has been made of an old railway tunnel—the Scotland Street Tunnel—in Edinburgh. The visitor to this excavation will find that, in place of railway sleepers and lines, the ground is occupied by carefully prepared beds, on which arise luxuriant crops of the favourite Agaric. Although in great request in this country, Berkeley, writing upwards of thirty years ago, states that it is "most carefully excluded from the Italian markets," owing probably to occasional poisoning symptoms that have shown themselves after its consumption. So far as we know, the Mushroom has never been known to have exhibited poisonous properties in this country. If the Italians are correct, we have a good example of the influence on a plant of its surroundings.

CROCODILES AND ALLIGATORS.

By R. LYDEKKER, B.A.(Cantab.)

IN spite of the circumstance that numerous examples of those ungainly reptiles known as Crocodiles and Alligators are exhibited in the reptile house of the Zoological Society's Gardens in a living condition, while their stuffed skins and articulated skeletons are displayed in the galleries of the Natural History Museum at South Kensington, there appears to be a hopeless confusion in the public mind between these two very different creatures. And, with the usual perversity of those not acquainted with the ordinary facts of natural history, residents in India increase this confusion by almost invariably speaking of the Crocodiles of that country as Alligators, whereas an Alligator is not to be found from one end of India to another. A remarkable instance of this confusion occurs in Sir S. Baker's "Wild Beasts and their Ways," where, under the heading of Crocodile, it is stated that, "as lizards are found distributed in great varieties throughout the world, in like manner we find the largest of all lizards, the Crocodile, under various names in nearly every river of the tropics. In America this reptile is generally known as an Alligator, and some persons pretend to define the peculiarity which distinguishes that variety from the Crocodile, but I regard the distinction in the same light as that between the leopard and the panther, the difference existing merely in a name."

Now, in the first place, although it may be justifiable in popular language to use the term lizard as applicable to all four-footed reptiles except tortoises and turtles, yet, scientifically speaking, a Crocodile has not the slightest right to be so termed. Indeed, it would be far preferable to speak of a snake as a kind of lizard, since it is really only a special modification of the lizard stock; and from a strictly scientific point of view it would imply far less confusion of ideas to call a cow a kind of pig than to term a Crocodile a lizard, since whereas a cow and a pig are mammals belonging to the same section of a single order, lizards and Crocodiles represent two totally distinct orders of reptiles. With regard to the statement that the difference between a Crocodile and an Alligator is merely one of name, the reader who follows us through this article will probably hold a different opinion by the time he reaches the end.

So far as external appearance goes, most people are aware that Crocodiles and Alligators are large, long-tailed, low-bodied reptiles, with flat and frequently broad heads, and their bodies protected by a coat of scales, which vary greatly in size in its different regions. They probably also know that it is the impressions of these scales, or of the bony scutes by which those of the back are underlain, that form the well-known markings on the Crocodile-skin now so commonly used for bags and other leather articles. In their short and clawed limbs there are five toes in the front pair, and four in the hinder, those of the latter being connected together for a part of their length by a web. As regards their habits, Crocodiles and Alligators are typical amphibious creatures, being perfectly at home in the water, but also capable of active progress on land, on which their eggs are laid and the young hatched. The position of their external nostrils at the very tip of the snout enables them to come to the surface for the purpose of breathing without showing more than their muzzle, or, at most, this and their somewhat prominent eyes. These external characters will enable us to recognize an Alligator or Crocodile when we see it, and yet do not show us how these creatures differ so essentially from true lizards as to render it incorrect to speak of them merely as a particular group of lizards. To render this essential distinction apparent we must enter into certain details of their anatomical structure, more especially as regards the skull. Now, in the first place, a Crocodile or Alligator may be at once distinguished from every true lizard by the circumstance that its large and pointed teeth are inserted in the jaws in distinct and separate sockets, from which they will readily fall out in a dried skull; whereas those of lizards, which vary greatly in form, are invariably united by solid bone with the edges or sides of the jaws, without any separate sockets. Moreover, in a Crocodile's shell, there is a bar of bone running backwards from the lower border of the eye-socket, or orbit (Fig. 1, *O*), to join the condyle with which the lower jaw articulates. This bar is seen in Fig. 1, below,

FIG. 1.—Side view of the skull of a Crocodile; *O*, eye-socket or orbit.

and to the left of the letter *O*, and also occupying the same relative position in Fig. 3. It will further be apparent from the latter figure that in a Crocodile's skull there are two parallel bars running backwards from behind the orbit, of which the upper one is the stoutest. Now in a lizard's skull, only the uppermost of these two bars is present; and we thus have a second important distinc-

tion between a Crocodile and a lizard. A still more important difference occurs, however, in the under part of the skull. Thus, whereas in a lizard the external nostrils open directly through the palate into the front part of the mouth, in a Crocodile the bones of the palate develop a kind of flooring beneath its roof, and thus form a closed passage by which the internal or posterior nostrils are brought to the very hinder extremity of the skull. This remarkable peculiarity is well exhibited in Fig. 2, A,

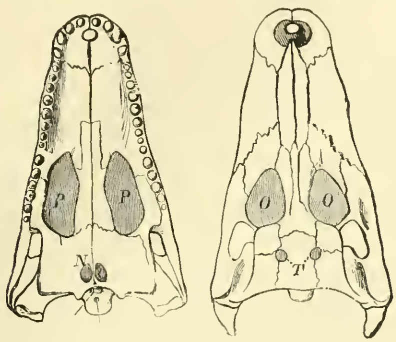


Fig. 2.—Lower view (A) of skull without the lower jaw, and (B) upper view of skull with lower jaw of a Crocodile. *O*, orbit; *T*, temporal pit; *P*, palatal vacuity; *N*, internal nostrils.

where *N* indicates the internal nostrils. The small round aperture seen in the front of the palate in both A and B is closed during life with membrane, and thus prevents any communication between the external nostrils and the front of the mouth. The object of this peculiar arrangement is to enable the animal to breathe when its mouth is open under water, and the nostrils are alone in the air; this being effected by the closing of the back of the mouth, in front of the internal nostrils, by means of a fold of skin, thus leaving a free communication between the nostrils and the wind-pipe. The advantage of this arrangement to animals which, like Crocodiles and Alligators, kill their prey by holding them under water, is self-apparent.

If to these differences between the skulls and teeth of Crocodiles and lizards, we add that, whereas in the latter the ribs articulate to the joints of the back-bone or vertebræ by means of little knobs on the sides of the vertebræ themselves, in Crocodiles they join the summits of long horizontal processes of bone projecting from the upper part of these vertebræ, we think we shall have said enough to convince our readers that it is altogether incorrect to speak of Crocodiles and Alligators as lizards. Crocodiles are, indeed, first cousins of those extinct reptiles which were described in a previous article in Knowledge as "Giant Land Reptiles," and they ought, therefore, to be regarded with respect as being the sole existing, although collateral, representatives of that great group of reptiles which dominated the earth at a time when mammals were only just beginning their career.

Having said thus much as to the distinctness of Crocodiles from lizards, we may proceed to consider how the former differ from Alligators, and to make some mention of a few of the various species of each. Now if we examine the skulls of the different kinds of Crocodiles we shall find that the number of teeth in the upper jaw varies from 17 to 19, while in the lower jaw there are invariably 15; and we shall likewise find that the teeth of the two jaws interlock with one another when the mouth is closed. Moreover, when the jaws are in opposition it will be observed that the first tooth on each side of the lower jaw is received into a pit in the palate of the skull, while the fourth lower tooth, which (like the first) is larger than the others, bites into a notch in the side of the skull (as shown in Fig. 1), and is thus more or less distinctly visible externally in the living animal. Crocodiles are now found in the rivers of Africa, India, Burma, Australia, and America, as well as in many of the larger islands in warm regions. They vary greatly in regard to the relative length of the skull, the longest-snouted species occurring in South America and West Africa, while those of India have the shortest and broadest skulls (Fig. 2). On the other hand, if we examine the skull of an Alligator, we shall find that the upper teeth bite on the outer side of the lower ones without any sort of interlocking, and both the first and the fourth lower teeth are received into pits in the skull, so that when the mouth is closed both of them are totally invisible from the outer side. Moreover, in no Alligator does the number of lower teeth ever fall short of 17. Again, in all Alligators the skull is even broader and shorter than in the Indian Crocodiles. Till within the last few years it was believed (in spite of the persistent assertion of sportsmen, that the Indian "Magars," as they are called by the natives, are Alligators) that Alligators were confined to the New World, but recently it has been found that there is one species in China. This is, indeed, a very curious instance of what is known as discontinuous distribution, and one which only finds a complete parallel in the case of the tapirs, of which there is one species inhabiting the Malay peninsula and adjacent islands, while all the others are restricted to South America. There are several species of Alligators, which are divided into two groups, according as to whether an armour of bony plates, or scutes, is or is not developed on the under surface of the body. In the true Alligators, which agree with all living Crocodilians in having a dorsal armour of these bony scutes, the number of upper teeth varies from 17 to 20, and that of the lower from 18 to 20, while there is no bony armour on the under surface of the body. The two well-known species are the Mississippi and the Chinese Alligator, in addition to which there is a third American form of which the exact habitat is unknown. The second group of Alligators, or Caimans, as they are called in Brazil, is confined to South America, where it is represented by five species. These are characterized by having from 18 to 20 upper, and from 17 to 22 lower teeth on each side, and also by having the lower surface of the body protected by a shield of bony scutes, which overlap one another like the tiles on a roof, and each of which is composed of two separate pieces united together by what is known as a sutural union.

The above, then, are the chief differences which distinguish Alligators and Caimans from Crocodiles, and they are such as surely do not justify the statement that naturalists merely pretend to distinguish between the two. Alligators and Crocodiles do not, however, exhaust the list of living Crocodilians, since we have two peculiar species differing from all the others by the great length of their snouts, and respectively inhabiting the Ganges and the rivers of Borneo—the former being known as the Gharial, and the latter as Schlegel's Gharial. In both of these reptiles the numerous teeth are long and slender, and differ from one another but little in size in different parts of the jaw, while neither of them have an armour on the lower surface of the body. They differ from Crocodiles and Alligators in feeding chiefly on fish.

In regard to their geological distribution, Crocodilians more or less closely allied to the existing Gharials, Crocodiles, and Alligators, are found throughout the rocks of the Tertiary period as far down as the London clay. Some of these extinct species were, however, of gigantic dimensions; one from the Siwalik Hills of India, which was allied to the Gharial, attaining a length of between 50 and 60 feet, and thus presenting a great contrast to living Crocodiles, which rarely exceed a length of some 22 or 23 feet. Another species found in the Tertiary clays of Hampshire presents characters intermediate between Crocodiles and Alligators, the fourth lower tooth being usually received into a pit in the skull, but the under surface of the body having a complete bony armour like that of the Caimans. This genus (*Diplocynodon*) differs from both Crocodiles and Alligators in that both the third and fourth lower teeth are larger than the adjacent ones, so that the animal had two powerful tusks in the sides of the lower jaw.

A few Crocodilians, more or less closely allied to existing types, also occur in the Cretaceous rocks, but when we reach the Wealden and Jurassic strata nearly all the forms differ very markedly from modern times, and show a lower stage of development. Before, however, we are in a position to understand how these early Crocodilians differ from their living cousins, we must enter a little more fully into the anatomy of the latter. Turning once more to Fig. 2, we see that the passage leading to the internal nostrils is formed by four pairs of bones, on the fourth of which the letter *N* is placed. Again, in all living Crocodilians the vertebræ articulate with one another by a ball-and-socket joint, of which the socket is situated at the front of each vertebra; this mode of articulation being the best adapted to give free motion of one vertebra upon the other. The third point we have to notice relates to the bony armour of living Crocodilians, in all of which the pitted scutes forming the shield on the back are ridged, and arranged in from four to eight longitudinal rows. Moreover, in the Caimans and the extinct *Diplocynodon*, the shield on the under surface of the body forms a single mass, made up of more than eight longitudinal rows of scutes, each of which, as already mentioned, consists of two separate pieces united together by suture.

If we now contrast these features with those obtaining in the Jurassic Crocodilians, we shall find very considerable differences. Thus in the skull of those reptiles the fourth pair of bones on the palate did not meet in the middle line below the passage to the nostrils, so that the internal nostrils were placed immediately behind, or sometimes partly between, the bones lying between *PP* in Fig. 2, and were thus much forwarder than in modern Crocodilians. Then, again, the vertebræ were slightly cupped at both ends, thus admitting of much less motion between one another. The armour on the back of the body is of a simpler type, consisting only of two longitudinal rows of scutes, which lack the longitudinal ridges so characteristic of those of the existing forms. On the other hand, the armour on the under surface was nearly always present and more developed, frequently consisting of two distinct portions, in the foremost of which the scutes (which consisted of a single piece) overlapped like slates, while in the hinder part they were joined by their edges to form a solid pavement of bone.

Like their modern cousins, the Secondary Crocodilians included both long-snouted (Fig. 3) and short-snouted types, the former being the more common and especially abundant in the Lias, where their remains occur in company with those of Fish-Lizards and Plesiosaurs. In many of these forms the pit (*T*) in the temporal region of the skull was larger than the socket of the eye, whereas in recent Crocodiles it is much smaller (Fig. 2), and in the Alligators may even disappear. A large number of these Jurassic forms were of marine habits, and a few of them attained enormous

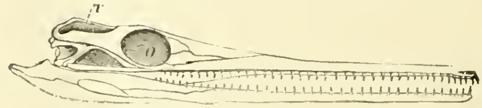


Fig. 3. Side view of the skull of an extinct Crocodilian of the Lias; one-fourth the natural size. Letters as in Fig. 1.

dimensions, the length of the skull of one species falling not much short of five feet. A few species are further peculiar in having altogether discarded their bony armour on both surfaces of the body.

Looking at Crocodilians as a whole, it is perfectly evident that they have advanced in complexity of organization with the advance of time, the backwardly placed internal nostrils and ball-and-socket vertebræ of the modern types being clearly an advance on the Jurassic forms. As, however, is the case in many similar instances, the gradual backward shifting of the internal nostrils presents a problem difficult to understand, as it is hard to conceive what advantage the species in which these nostrils were situated in the middle of the palate had gained over reptiles in which they were placed near the muzzle, the completely backward position being apparently essential in order that the mouth might be kept open under water.

With regard to the general disappearance of the inferior body-armour and the invariably increased development of that on the back of the recent forms, it may be suggested that, as most of the Jurassic Crocodilians were of marine habits, and probably swam far out to sea, it would have been highly advantageous for them to have the lower surface of the body protected from attacks from below by sharks and other creatures. On the other hand, since modern Crocodiles and Alligators spend a considerable portion of their time on the banks of rivers, and when in the water are in the habit of reposing or crawling on the bottom, it is obvious that the back is the portion which requires especial protection. An explanation of the existence of an armour on the lower surface of the body in the Caimans is less easy to give, although it may be merely an instance of the retention of an ancestral character.

We may conclude this account by referring to some interesting observations recently made by Dr. Voeltzkow on the eggs and embryos of the Crocodile of the Nile. It appears that in Madagascar the egg-laying lasts from the end of August to the end of September, the number of eggs in a nest varying from twenty to thirty. The nest is dug about two feet deep in the dry white sand; the bases of its walls are gouged out, and into the lateral excavations thus formed the eggs roll from the slightly raised centre of the floor of the nest. Externally the nest is not discernible, but the parent sleeps upon it. The eggs differ greatly in form; the shell is white, thick, firm, and either rough or smooth, the double shell-membrane being so strong that the egg keeps its form after the shell has been removed. When newly laid the eggs are very sensitive, and are readily killed by damp or by heat, but the older eggs are hardy. When the young embryos are about to be hatched, they utter distinct notes, which the mother hears, even through two feet of sand, and proceeds to dig open the nest. Before hatching the embryo turns, and in so doing partially tears the fœtal membranes. With the tip of its snout turned to one end of the egg, the young animal bores through the shell with a double-pointed tooth comparable to that which young birds possess. This tooth appears very early—by the time the embryo is six weeks

or two months old—and may still be seen a fortnight after hatching. Through the small perforation made by this tooth the fluid flows out, softening the adjacent parts, so that the aperture is widened into a cleft. The process of creeping out may take about two hours. The young animal seems large in comparison with the egg; one measuring 28 cm. in length came out of an egg 8 cm. long and 5 cm. broad. The young Crocodiles are wild little animals, and are led to the water by the mother. They utter sounds, especially when hungry, but the pitch of their call is not so high as it was when they were within the egg.

ON THE MASS AND BRIGHTNESS OF BINARY STARS.

By J. E. Gore, F.R.A.S.

The orbit of a binary star having been computed, and its distance from the earth determined, it is easy to calculate the combined mass of the components in terms of the Sun's mass. We can also compare the brightness of the star with that of the Sun, for as the brightness decreases as the square of the distance, we can compute how much the Sun's light would be reduced if removed to the distance of the star. Photometric comparisons have shown that the Sun's stellar magnitude is about —25·5, on a scale of which the "light ratio" is 2·512. In other words, the Sun is $25\frac{1}{2}$ magnitudes brighter than a star of the zero magnitude, or $26\frac{1}{2}$ magnitudes brighter than an average star of the first magnitude, like Altair or Spica. The parallax of some of the binary stars has been ascertained, and although the results found are perhaps in some cases of rather doubtful value, an examination of the mass and brightness indicated by the most careful measures of the distance may prove of interest to the reader.

We will take the stars in order of right ascension:—

1. η Cassiopeiæ.—For this well-known binary star a parallax of 0·3743″ has been found by Schweizer and Socoloff. Several orbits have been computed, none of which are quite satisfactory, but assuming Grüber's period of 195·235 years, and semi-axis major of 8·639″, I find the mass of the system equal to 0·32 of the Sun's mass. The star was measured 3·41 magnitude, with the photometer at Oxford, and 3·64 at Harvard. We may, therefore, assume its magnitude at 3·5. Taking the Sun's stellar magnitude at —25·5, I find that if placed at the distance indicated by the above parallax the Sun would be reduced to a star of magnitude 3·2, or only slightly brighter than η Cassiopeiæ. As the companion is only $7\frac{1}{2}$ magnitude, it will not appreciably affect the light of the star, and as the spectrum is of the second or solar type, it should be fairly comparable with the Sun. If the mass were equal to that of the Sun, the parallax would be 0·256″, and at this distance the Sun would be reduced to a 4th magnitude star. Struve found a parallax of 0·154″. Its comparatively large proper motion of about 1·2″ per annum would indicate a comparative proximity to our system.

2. 40 Eridani.—The binary companion of this triple star is of about the 9th magnitude, and is probably physically connected with the bright star, as all three have a common proper motion. A parallax of 0·223″ has been found by Professor Asaph Hall. This, combined with the orbit computed for the binary pair by the present writer, gives a mass equal to the Sun's mass—a result which is remarkable, for the Sun, placed at the distance indicated by the parallax, would shine as a star of 4·3 magnitude, or about the brightness of the principal star of 40 Eridani. This result implies that the Sun is about 76 times brighter than the binary pair. Owing to the faintness of the binary star, the character of its spectrum has not been determined. Computed by a well-known formula, its "relative brightness" is very small, but only one orbit has yet been computed, and this will require revision when furthur measures are available. The proper motion of the system is very large, about 4·1″ per annum.

3. Sirius.—The great brilliancy of this star—the brightest in the heavens—naturally suggests a sun of great size. Recent investigations do not, however, favour this idea. Assuming a parallax of 0·39″ (about a mean of the results found by Elkin and Gill) and the elements of the orbit computed by the writer, the mass of the system would be 3·114 times the mass of the Sun. Placed at the distance of Sirius the Sun would be reduced to a star of 3·1 magnitude. As Sirius is about one magnitude brighter than the zero magnitude, it follows that it is about four magnitudes, or about forty times brighter than the Sun would be in the same position. Were it of the same density and brightness as the Sun, the mass found above would indicate that its diameter should be 1·463 the solar diameter, and its brightness 2·1324 the solar brightness. The spectrum is, however, of the first type, and the star is, therefore, not comparable with the Sun in brilliancy. The result would indicate that stars of the first, or Sirian type, are intrinsically brighter than the Sun.*

4. Castor.—Assuming a parallax of 0·198″ found by Johnson, and a period of 1001·21 years found by Doberck (a=7·43″), I find the sum of the masses of the components of Castor only 0·052692 of the Sun's mass, a result which would imply that the components are gaseous masses. Johnson's parallax is, however, of doubtful value. Placed at the distance indicated, the Sun would be reduced to a star of 4·5 magnitude. The magnitude of Castor is about 1·55, so that it is (according to the assumed parallax) about three magnitudes, or about sixteen times brighter than the Sun would be in the same position. The spectrum is of the first type, another example of the great brightness of the stars of this type. According to a well-known formula, the "relative brightness" of Castor is thirty-eight times that of the binary star, ξ Ursæ Majoris, taken as a standard. The latter star has a spectrum of the second type.

5 α Centauri. This famous star, the nearest of all the stars to the earth, as far as is at present known, forms an object of especial interest, particularly as its spectrum is, according to Professor Pickering, of the second or solar type, although with some peculiarity. Combining Dr. Gill's parallax of 0·76″ with Downing's elements of the orbit (P=76·222 years, a=17·33″), I find that the mass of the system is 2·04 times the mass of the Sun. Placed at the distance of α Centauri the Sun would be reduced to a star of about 1·7 magnitude, or about one magnitude fainter than the star appears to us. This would indicate that α Centauri is about two and a half times brighter than the Sun, and its mass (if of the same density) about four times the solar mass. As, however, there is something peculiar about the spectrum, the density and intrinsic brightness of α Centauri may be somewhat different from that of the Sun.

6. 70 Ophiuchi. This is another star which is fairly comparable with the Sun, as its spectrum is of the solar type, according to Vogel. The orbit found by the present writer (P=87·84 years, a=4·50″), combined with Kruger's parallax of 0·162″, gives for the combined mass of the components 2·777 times the mass of the Sun. The star was measured 4·11 magnitude with the photometer at Harvard Observatory. Placed at the distance indicated by the

* Or that they are of less density than our Sun.—A. C. Ranyard.

parallax, the Sun would be reduced to 5·0 magnitude. This would make 70 Ophiuchi about 2·27 times the brightness of the Sun. According to Dembowski there is a difference of 1·7 magnitude between the components. If we assume that each has the same density as the Sun, I find that the combined mass of the two stars would be 2·825 times the solar mass, which agrees closely with the result found from the orbit. We may, therefore, conclude that Krüger's parallax for this star is not far from the truth. The diameters of the components would be about 1,188,000 miles, and 542,000 miles, and the distance between them 27·77 times the Sun's distance from the earth, or somewhat less than the distance of Neptune from the Sun.

7. 85 Pegasi.—For this binary pair, a somewhat doubtful parallax of 0·054″, found by Brünnow, combined with Schaeberle's elements of the orbit (P=22·3 years, a=0·96″), gives a mass of 11·3 times the Sun's mass. Placed at the distance indicated, the Sun would be reduced to a star of 7·41 magnitude. 85 Pegasi was measured 5·83 magnitude with the photometer at Harvard, so that the star is 1·58 magnitude, or 4·286 times brighter than the Sun would be at the same distance. If of the same density, its mass would, therefore, be 8·872 times the solar mass, a result not differing very widely from that found from the orbit. As, however, I have no information of the character of the star's spectrum, I cannot say whether or not it is comparable with the Sun.

It seems to be still very doubtful whether 61 Cygni is really a binary star, but assuming a parallax of 0·45″, and the star's magnitude at 5·11, as measured at Harvard, I find that the Sun is about 8·39 times as bright as 61 Cygni, and its mass, therefore, considerably greater. The star has, according to Professor Pickering, a peculiar spectrum of the solar type.

Let us now consider the close binary stars recently discovered with the spectroscope, and which are known as "spectroscopic binaries." With reference to Algol, which may be considered as a binary pair, in which one of the components is a dark body, Professor Vogel finds that the combined mass of the system is about two-thirds of the Sun's mass. From the dimensions he gives for the components, I find that their mean density is about one-third that of water, so that they are probably gaseous bodies. As the parallax of this star has not yet been determined, we cannot say what the Sun's magnitude would be if placed at the star's distance, but as the spectrum of Algol is of the first or Sirian type, we may conclude that it is bright in proportion to its mass.

For ζ Ursæ Majoris (Mizar) Professor Pickering finds a mass equal to forty times the mass of the Sun. Klinkerfues found a parallax of about 0·045″ for this star. At this distance the Sun would be reduced to a star of only 7·8 magnitude. The Harvard measure of ζ Ursæ is 2·38. It is therefore 5·42 magnitudes, or 147 times brighter than the Sun would be at the same distance. It should therefore be, if of the same density, 1787 times the mass of the Sun. But the spectrum is of the first type, and the star is therefore not comparable with the Sun in its physical constitution. We have here another example of great brightness in proportion to mass.

β Aurigæ was discovered to be a close binary with the spectroscope at Harvard Observatory, and the discovery has been fully confirmed by the observations of Professor Vogel at Potsdam. The period is about four days, and the distance between the components about 16 millions of miles. From these data I find that the mass of the system is about five times the mass of the Sun. Recent photographic measurements by Professor Pritchard at Oxford have yielded a parallax of 0·059″ and 0·065″ (*Observatory*, June, 1891). Taking a mean of these results, or 0·062″, we have the Sun reduced to 7·17 magnitude if placed at the distance of the star. β Aurigæ was measured 1·94 magnitude at Oxford and 2·07 at Harvard. We may therefore assume its magnitude at 2·00. This gives a difference of 5·17 magnitudes between the light of the Sun and that of β Aurigæ. In other words, β Aurigæ is 117 times brighter than the Sun would be if placed in the same position. If therefore of the same intrinsic brightness of surface its diameter would be 10·8 times the diameter of the Sun, and its volume 1265 times the Sun's volume. We see, therefore, that—like Sirius—this star is very much brighter than the Sun in proportion to its mass. As the spectrum of β Aurigæ is of the first or Sirian type, we have here another example of great brilliancy in proportion to mass, a feature which seems characteristic of all stars of the Sirian type.

Spica.—The spectroscopic observations of this bright star indicate a mass of about two and a half times the mass of the Sun. The parallax has not yet been well determined (Brioschi found a negative parallax), but judging from its small proper motion, the star's distance is probably very great. As it is a standard star of first magnitude, its brightness would seem to be enormous in proportion to its mass, and here again we have a spectrum of the Sirian type.

We may therefore conclude that binary stars with spectra of the first type—and probably all stars of this type—are very bright in proportion to their mass, while those showing spectra of the second or solar type are intrinsically much less luminous and have a brightness approximately proportional to their mass.

Many of the parallaxes made use of by Mr. Gore in these calculations are no doubt extremely doubtful. But in such an enquiry, even the roughest estimates are of value. The evidence collected tends to indicate that stars of the Sirian type are either less dense than the Sun—that is, that they are in an earlier stage of condensation—or that their photospheres are more brilliant, area for area, than the solar photosphere.—A. C. Ranyard.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

PERMUTATIONS AND COMBINATIONS.

To the Editor of Knowledge.

Dear Sir,—It has occurred to me that the solution of interesting questions concerning the number of possible changes or permutations in the arrangement of things is often rendered impossible to most persons in consequence of the great labour involved in the mere arithmetical process of computation. I am quite aware that the higher mathematics has furnished us with a formula, including functions of π and ϵ, by means of which the factorials of high numbers are obtainable with as great a degree of exactness as the use of logarithms will afford; but, when very great numbers are under consideration we never want exactness—nor could we obtain it if we did. Some numbers are so bewilderingly vast that it would take years even to write them down in figures; such numbers can only be apprehended by means of their logarithms, or, which comes to the same thing, by the statement how many figures they take. The same thing applies, though in a less degree, to numbers not quite so enormous. When

we are told a certain number of things can be arranged in more than a decillion of ways, or, in mathematical language, that the factorial of a certain number is upwards of a decillion, our curiosity is equally satisfied in being told that the number would take more than 60 figures to write it down; which, again, is the same thing as saying that its logarithm is greater than 60. Such being so, all we really require in these cases is a simple formula, by means of which we can obtain the integral part of the logarithm—the error being only in the fractional part.

Such a formula I think I have discovered, but whether already known I cannot say. It may briefly be stated thus:—That the factorial of any number n is approximately, in the above manner, equal to

$$(\cdot 37\ n+1)^n$$

This formula may be used, say from 13 to 650.

To show that this is really the case, I give below the logarithms of a few factorials, together with those of the corresponding values by the formula.

Number.	Log. of Factorial.	Log. of Formula.	Diff.
13	9·79	9·93	0·14
16	13·32	13·42	0·10
21	19·71	19·80	0·09
40	47·91	47·95	0·04
81	120·76	120·77	0·01
100	157·97	157·98	0·01
300	614·49	614·77	0·28
600	1408·10	1408·98	0·88

When the factorials of numbers *greater* than 650 are required, it is better to substitute ·368 for ·37 in the formula. This will give a more extended range; thus—

Number.	Log. of Factorial.	Calculated with ·368.	Diff.
1000	2567·60	2567·03	0·57
1100	2869·73	2869·14	0·59
1500	4114·68	4114·09	-0·59
5000	16325·58	16325·27	0·31
7500	25808·09	25808·00	0·09
9000	31681·91	31681·99	+0·08
10,000	35659·45	35659·66	+0·21
11,000	39680·50	39680·83	+0·33

Between 15,000 and 20,000 the error commences to extend into the characteristic or integral part of the logarithm. Accordingly, if the same nearness is required for still greater numbers, another fraction would have to be substituted for ·368. But for most purposes I should imagine that either ·37 or ·368 will serve.

T. S. BARRETT.

[Mr. Barrett's useful formula will be more readily remembered by observing that it approximates, when n becomes very great, to $(\frac{n}{e}+1)^n$. This may be easily proved from De Morgan's formula* for $1 \times 2 \times 3 \times \ldots$ up to n—$\lfloor n = \sqrt{(2\pi n)}\, n^n e^{-n + \frac{1}{12n} - \frac{1}{360}\frac{1}{n^3} + \ldots}$—A. C. RANYARD.

ON THE RED STARS NEAR THE CYGNUS NEBULA, DETECTED BY DR. WOLF.

To the Editor of KNOWLEDGE.

SIR,—The very remarkable photographs of Dr. Max Wolf of the region about α Cygni, showing a large mass of nebulous light, and your interesting article published in the October number of KNOWLEDGE, led me to compare the photographs with the charts of Argelander. Any red star would at once be recognizable, on account of the difference between its actinic light and its brightness as seen with the eye. All stars showing any such difference were marked on the charts, and subsequently examined with the telescope. The region is not abnormally rich in known red stars. Only three fourth-type stars have hitherto been detected in this region; two others are suspected to be of type IV. The red region of Cygnus lies somewhat to the south of the α Cygni photograph, and all the Wolf-Rayet stars, save one, are also to the south. The telescope used was a $17\frac{1}{4}$-inch reflector, with a power of 70, and where there was sufficient light the stars were examined with the spectroscope, but no new fourth-type stars were detected, though several new third-type stars were discovered. The work was carried on during the evenings of September 9th, 10th, 29th, October 1st, 2nd, 3rd, after I had first seen a print of Dr. Wolf's photograph lent me by Mr. Ranyard, and in all 159 stars were examined. The classification by colour is the same as that used throughout the "Red Star Catalogue." The following red stars were detected:—

Red and orange red	23	
Pale orange red	38	
Slightly tinged with red	36	Total 97

The remaining stars show nothing of interest, being usually fainter than the 9·5 magnitude of Argelander. Nine stars, however, are now only of the 11·0 magnitude, or less, and several, if not all, will probably turn out to be variable. The boundaries of the smaller photograph are in right ascension 20h. 14m. to 21h. 0m. roughly, and in declination + 39° to + 50°. The number of stars in Argelander is 3011. On page 194 of the "Red Star Catalogue," a method is given of finding the probable number of red stars; this is, number of stars × ·0075. Multiplying the number of stars in Argelander by this quantity, we get 23, which accords exactly with the number of stars actually observed. It would seem, therefore, that there is no abnormal quantity of red stars in this region. In the next place, the whole of the stars which showed any colour were marked with red on the photographs to see if they were distributed according to any rule. Only one star, and this pale orange red, was found in the nebula. Generally speaking, the coloured stars seem to lie on the borders or between the groups or streams of stars. A curious and slightly curved line of four nearly equidistant coloured stars extends from α Cygni to the preceding edge of the photograph. Another curve of five stars is associated with γ Cygni. The north part of the photograph, especially where the stars rapidly decrease in number, seems richer in coloured stars, and on extending the sweeps yet further north this fact is very obvious. As regards the minute stars, I am inclined to believe that none are beyond the range of the $17\frac{1}{4}$ reflector. The *minimum visibile* of the $17\frac{1}{4}$ has been found to be 15 magnitude on Argelander's scale, and though only one field has been examined, yet from the results it would seem that the smallest stars are within the limit of 15 magnitude. Only three red variable stars known at the present time lie in this region, two of them following α Cygni, and north of it; still further to the north and on the following side of the photograph, but beyond it, lie three other variable stars. Finally, the brighter stars in the immediate vicinity of the nebula were examined with a powerful spectroscope, and seen to be generally first-type, with strongly marked hydrogen lines. It was thought possible that some of them might show bright lines, as in the case of stars associated with the nebula in Orion, but no such star was detected. The nebula is visible in the $17\frac{1}{4}$, as a faint haze.

Towlaw, Darlington. T. E. ESPIN.

[I hope in a future number to give a photo-etching of the stars in the α Cygni region with Mr. Espin's new red stars marked upon it. I should be glad if other observers with large telescopes would compare the stars they can see in this region with those shown in the plate

* *See* De Morgan's "Differential Calculus," p. 312.

published in the October number of Knowledge. I have only had an opportunity of examining the region under unfavourable circumstances with an 18-inch reflector. It seemed to me that the photograph showed many more faint stars than I could reach with the telescope, and I could only detect the brightest parts of the nebulous regions.—A. C. Ranyard.]

To the Editor of Knowledge.

Sir,—There is some confusion in your September and October numbers with reference to the magnitude of Canopus: the magnitude 0·4 quoted in the list on p. 91 is on the *Uranometria Argentina scale*: the magnitudes of the other stars, except α Centauri, are on the scale of the Harvard Photometric Catalogue, and the two scales are not comparable. Herschel's magnitudes are evidently not photometric, and this introduces a new scale, and accounts for the apparent faintness of Sirius. Thome gives the magnitude of Canopus in 1885 as $-0·6$ with Zöllner's Photometer. The agreement is therefore complete as to Canopus being the second brightest star in the heavens.

In the October number, page 193, 2nd column, line 8, "ζ Cancri" should read "S Cancri."

Yours truly, T. W. Backhouse.

THE UPPER ATMOSPHERE.

By A. C. Ranyard.

I AM enabled this month, through the kindness of Mr. Shadbolt, to lay before the readers of Knowledge some photographs taken from balloons at various altitudes. Mr. Shadbolt is a very experienced amateur aeronaut who has made over sixty ascents, and he was, I understand, the first to take a recognizable photograph from a balloon, in June, 1882. The rays of light which fall on a photographic plate exposed from a balloon have had to pass twice through the densest and most dust-laden strata of the atmosphere. Even in photographing distant landscapes from the surface of the ground very little detail is ordinarily obtained upon distant hills, owing to the absorption of the photographically active rays in passing through a great distance of the lower atmosphere. But the difficulty is greatly increased in attempting to photograph the distant earth from a great altitude in a balloon, for not only is the absorption increased by the long course of the rays through the lower air, but the observer sees the dust-motes in the atmosphere from their sun-illuminated side. The veil of haze spread over the earth, therefore, hides the objects behind it more effectually than the transparent veil of haze which we ordinarily see over a distant landscape, giving the soft effects of distance which artists so well know.

An observer with a giant telescope, on Mars or on the Moon, would probably see much less of what is going on on the surface of the earth than we are apt to imagine. The white upper surfaces of the clouds would first attract his attention, with, in between them, a very dim and hazy view of objects on the earth's surface, rendered all the more difficult to observe by the frequent presence of a dazzlingly bright patch of sunlight reflected from the sea. To a naked eye observer on Mars, the earth would probably appear like a variable star, with a curious and mysteriously irregular period of variation, due to the change in the brightness of the specularly reflected patch of sunlight as terrestrial clouds covered it up, or the rotation of the earth brought continents or seas to the part of the earth's surface from which specular reflection could take place.

The exposure of photographs taken from a balloon must necessarily be short, for the balloon generally drifts along with considerable velocity, and sometimes it revolves. The revolution is, however, never very rapid, and it is generally more noticeable as the balloon descends than as it rises, owing to the greater irregularity of the car and under-surface of the balloon as compared with the comparatively spherical surface which it presents to the air on rising. With reference to the velocity with which balloons travel, Mr. Shadbolt is of opinion that they do not, as a general rule, travel so rapidly when at a considerable altitude as they do when nearer to the earth. Since this is contrary to the usually received opinion with regard to the velocity of the wind at various altitudes, and Mr. Shadbolt's judgment is founded on very full notes which he takes, during his balloon voyages, as to the time of passing over various places, I give the following extract from a letter he obligingly wrote me on the subject. Mr. Shadbolt says: "I have invariably found the wind near the earth, say up to 1500 or 2000 feet, to be stronger than at higher altitudes. I have frequently mounted up to take refuge from an approaching squall, and it has overtaken the balloon and passed below it, while nearly always when above the clouds they appear to travel along at a more rapid speed, and to pass along beneath the balloon. The same thing is noticeable when there are no clouds; you take your bearings and scarcely seem to be moving until you drop down near to the earth. Some might say that this would naturally be due to the distance you are from the objects below, making a quick movement appear to be slow, but after some practice you learn to recognize the actual rate at which you are passing over the ground below you."

At considerably greater heights in the air than balloons have ever attained to, the wind is known occasionally to blow with a velocity of over 140 miles an hour. Thus the dust from the explosion of Krakatoa, which took place on 27th August, 1882, was carried to the West India Islands (half round the earth) in seven days, and the average velocity of the wind at mountain observatories greatly exceeds the average velocity observed at the sea level. A passenger in a balloon hardly feels the wind from the time he starts till the time he touches earth again, for though a high wind may be blowing he is carried along with it, and only feels a slight wind when the balloon, in rising or falling, passes from one current into another, and then the sensation only lasts until the balloon has taken up the velocity of the current of air into which it has passed. The greatest altitude which has been attained by a balloon seems to be a little over seven miles. Mr. James Glaisher and Mr. Coxwell ascended from Wolverhampton on the 5th September, 1862, and are believed to have reached an altitude of 37,000 feet, at which height the barometer would only stand at seven inches. Mr. Glaisher's last reading in ascending was made at a height of 29,000 feet, after that he became insensible, and Mr. Coxwell, at the greatest height attained, lost the use of his hands, and was obliged to pull the cord (which opened the valve and caused them to descend) by seizing it with his teeth and bowing his head downward.

The altitude attained by Messrs. Glaisher and Coxwell, though higher than the highest mountain, sinks into insignificance compared with the total height of the ocean of atmosphere which surrounds the earth. Small clouds may occasionally be observed at a height of ten miles*

* Mr. H. P. Curtis, of Boston, tells me that the towering cumulus clouds over thunderstorms on the American prairies may sometimes be seen on the horizon at a distance of 200 miles; proving that they occasionally attain an altitude of over five miles.

1.—Taken from a Balloon by Mr. CECIL V. SHADBOLT, at a height of 500 feet over Silvertown. Shows the Thames and Woolwich Dockyard buildings in the foreground, with a distant view over Kent. 13th August, 1884.

2.—Taken from a Balloon by Mr. CECIL V. SHADBOLT, at a height of 6000 feet over Belvedere. Shows the Thames in the foreground, with jetty running out into the river. 17th August, 1889.

3. —**Taken from a Balloon** by Mr. CECIL V. SHADBOLT, at a height of 2100 feet over Lewisham (reversed right and left).

4.—**Taken from a Balloon** by Mr. CECIL V. SHADBOLT, at a height of 1500 feet over Beckenham (reversed right and left). 1st August, 1887.

above the sea level ; and observations of the duration of twilight show that a glimmer of light may generally be traced till the sun is 18° below the horizon, which indicates that there is matter capable of dispersing the sun's light at an altitude of about 40 miles. On ordinary occasions the air above that altitude is either too rare, or too pure from foreign particles, to disperse any perceptible amount of twilight. After the explosion of Krakatoa the sunset colours and the longer duration of twilight showed that dust was suspended in the upper atmosphere for many months, at considerably greater altitudes than usual, probably at a height of at least 60 miles. It has been suggested that the volcano threw the dust to an altitude of a few thousand feet, and that it was then carried into the upper air by the rising heated atmosphere of the tropics, which always gives rise to an upcast current carrying the air from near the surface of the ground to a great altitude, and dispersing it and the dust it contains north and south into either hemisphere. But as similar sunset effects were observed in the last century extending over Europe after the great eruption of Skaptar Jokul in Iceland,* it is probable that the heated column of air over the volcano itself would be sufficient to carry dust into the higher regions of the atmosphere.

The smaller shooting stars generally become visible at a height of from 70 to 80 miles above the earth, and they are usually entirely consumed before they penetrate to 50 miles above the sea level, but there is ample evidence that larger meteors have occasionally been observed at a height of over 100 miles above the earth's surface, proving that there is sufficient atmosphere at such great altitudes to resist their motion and convert a part of their energy of translation into heat and light sufficient to render them visible.

The air at these great altitudes must be very rare, much rarer than the vacuum within the bulb of an electric incandescent lamp, for the density of the atmosphere is halved at a height of about three and a half miles, and we know that with an atmosphere composed of gas, which obeys Boyle's law connecting the density with the pressure, the density will continue to be halved with every additional ascent of three and a half miles; consequently at a height of 70 miles the density will have been reduced in the proportion of 1 to 2^{20}, that is, the atmosphere will have less than a millionth of the density of the air at the sea level, which about corresponds to the density of the air within the bulb of an electric lamp (usually spoken of as the vacuum). At a height of 105 miles the density of the air will have been reduced in the proportion of 1 to 2^{30}, or more than a thousand million times.

The reason for this rapid decrease in geometrical progression of the density of the atmosphere as we ascend is easy to see when we consider the pressure on each stratum of three and a half miles in thickness as we rise above the earth's surface. The lowest stratum, which contains a half of the atmosphere, is compressed by the weight of the upper half of the atmosphere that rests upon it. The next quarter of the atmosphere will occupy a stratum of the same thickness as the lowest half of the atmosphere, because every part of it will be compressed with just half of the weight which compresses a similar stratum of the lowest half, and the atmosphere is composed of gases which very approximately obey Boyle's law ; that is, the volume varies inversely as the pressure. In the same manner the third stratum of three and a half miles in thickness will contain an eighth part of the whole atmosphere under the pressure of the weight of the remaining eighth part above it, and the fourth stratum will contain a sixteenth part under the pressure of the weight of the remaining sixteenth part, and so on.

The successive steps at which the density of the earth's atmosphere is halved will in fact become shorter and shorter as the temperature falls in the upper air, for the volume occupied by a mass of gas depends upon its temperature as well as the pressure upon it. While the pressure remains constant the volume varies as the absolute temperature. Thus, if the height of the lower half of the atmosphere at a temperature of 32° Fahr., or 0° Cent., were exactly three and a half miles, its height at a temperature of T degrees would be $\frac{T}{273} \times 3{\cdot}5$ miles, where T is the absolute temperature measured in degrees Centigrade. We know that the temperature falls very rapidly in the upper air; thus, at the greatest height reached by Mr. Glaisher on the 5th September, 1862, the temperature of the air as registered by a minimum thermometer fell to —11·9° Fahr., at a height where the pressure of the atmosphere was only reduced to about a quarter of the pressure at the sea level. If at a height of 70 miles the temperature falls to −91 Cent., the height of the successive steps of the above series will be reduced to two-thirds of the height of the lowest half of the atmosphere—that is, the density of the atmosphere would be halved at successive steps of a little less

* Gilbert White, of Selborne, in one of his letters to the Hon. Danes Barrington, describes "the amazing and portentous phenomena" observed in the summer of 1785. He says the sun "shed a rust-coloured ferruginous light on the ground, particularly lurid and blood-coloured at rising and setting." There are many references to the "red fog" which caused great alarm over Europe during the whole of the summer of 1783. Lalande ascribed it to the effect of a hot sun succeeding a long period of heavy rains, and Cowper refers to it in "The Task." Book II., lines 53-65, which were written in the autumn of 1783; he also refers to the earthquakes and tidal waves of that year. Mrs. Somerville, in her "Physical Geography," traces the origin of these phenomena of 1783 to the great eruption of Skaptar Jokul, which broke out on May 8th and continued till the end of August, sending forth immense quantities of dust as well as lava. Sir John Herschel, in his "Physical Geography," states that Skaptar Jokul ejected 21 cubic miles of lava, a quantity equal to the volume of water poured by the Nile into the sea in a year.

than two and a half miles, so that we have considerably under-estimated the actual rate of decrease of the density of the atmosphere on mounting upwards.

Let us assume that the density of the air at a height of 100 miles is reduced to a thousand-millionth of the density of the atmosphere at the sea level, we are still very far from having got rid of the atmosphere altogether. According to recent estimates, founded on curious corroborative evidence derived from more than one class of physical phenomena, a cubic inch of such tenuous atmosphere would contain about 350 thousand million molecules of gas; a number which is so enormous that its vastness can only be partly realized by means of an illustration. Let us suppose a small bulb of one inch cubic capacity to be filled with air of a thousand millionth, the density of atmospheric air at the sea level. If the bulb were imperfectly sealed so that a thousand molecules could rush into it in every second of time, it would take more than eleven years for the pressure inside the bulb to become doubled—that is, for as many more molecules to rush through the leakage as were originally contained in the bulb.

If the pressure of the air continues to decrease according to the same law, as we proceed upwards its density will have been decreased to one million million millionth part of the density at the sea level at a height of 200 miles, and a cubic inch of such air would contain only about 350 molecules; and at a height of less than 222 miles, a cubic inch would only contain one molecule.

At what height should we reach the surface of the atmosphere? Many people, whose opinions are entitled to respect, have thought that the air has not an upper limit. Professor Young, in his "Text-book of General Astronomy," in dealing with the height of the atmosphere (sec. 98), is cautious, and says that it cannot "be asserted positively that the atmosphere has any definite upper limit." But Professor Förster, of Berlin, in a paper which he read before the German Geographical Society* in May last, brings together evidence which he thinks proves the existence of a "Himmelsluft," or thin air pervading in greater or less density the whole of the solar system, and which he assumes is associated with the strata of extremely rarefied gases, which follow the earth's movements round the sun. He quotes, as evidence of such a medium, the retardation of Encke's comet when near to perihelion, and the appearance of the zodiacal light and the "gegenschein," or "counterglow," which has been so frequently observed, as well as some other evidence which appears to be very doubtful with regard to the height of luminous clouds and the aurora.

The retardation of comets near to perihelion may be satisfactorily accounted for by the great extension of coronal matter about the sun, and the appearance of the zodiacal light and the "gegenschein" may be due to the light dispersed by flights of meteors which seem to be aggregated near to the plane of the ecliptic and not to be evenly dispersed about the sun, as would be the case if an atmosphere filled inter-planetary space. But the kinetic theory of gases seems to afford evidence that the molecules of the atmosphere do not escape from the region of the earth's attraction. According to the kinetic theory the molecules of hydrogen, at a temperature of 0° Cent., move with an average velocity of a little more than 6000 feet per second. Clerk Maxwell, in his "Theory of Heat," 9th edit., p. 314, gives their average velocity as 6097 feet per second. The atomic weight of nitrogen is 14·01; consequently, assuming Clerk Maxwell's velocity for hydrogen, the molecules of nitrogen at a temperature of 0° Cent. will move with an average velocity of 1629 feet per second, and the molecules of oxygen, the other chief constituent of the atmosphere, will move a little more slowly. The square of the mean velocity varies as the absolute temperature; consequently, as the temperature is lowered the average velocity of the molecules decreases rapidly, and we may feel quite confident, from observations made in balloons and at mountain observatories, that the temperature near to the limits of the atmosphere is far below 0° Cent. We shall therefore be certainly much above the mark in assuming an average velocity of 1629 feet per second for the molecules of nitrogen in the highest strata of the atmosphere, where their free path becomes very long, and some of them can escape upwards without suffering a collision. A projectile thrown upwards from such an altitude under the influence of the earth's gravity, with a velocity of 1629 feet, would be carried to a height of less than nine miles above the point at which it started and would fall again into the atmosphere. It would require a velocity more than twenty-two times as great, or of about seven miles per second, to carry it away from the earth. The velocities above referred to are the mean velocities of molecules at a temperature of 0° Cent. We know that the actual velocities of the molecules will be distributed about the mean velocity according to the law of probable error, and it seems very improbable that in the extremely cold upper regions of the atmosphere any molecules will have a sufficiently great upward velocity to be carried outside the region of the earth's attraction.

* An abstract of this paper is printed in the "Proceedings of the Royal Geographical Society of London" for July, 1891.

Notice of Book.

On the Adjustment and Testing of Telescopic Objectives (published and sold by T. Cooke and Sons, Buckingham Works, York; price 5s.).—This little book will be greatly welcomed by observers, as teaching them how to adjust and test the adjustments of their object-glasses and mirrors. The illustrations are excellent, particularly the frontispiece, which shows the various appearances of star discs as seen in and out of focus, with perfect and defective object-glasses, and with a good instrument when badly adjusted. The authorship of the work is not stated; it appears to be a joint-production of persons possessing very considerable practical as well as theoretical knowledge.

METEOROLOGY OF BEN NEVIS.

By Dr. J. G. McPherson, F.R.S.E.

(*Lecturer on Meteorology in the University of St. Andrew's.*)

BEN NEVIS, in Inverness-shire, is not only the highest mountain in Scotland, but also the highest in the British Islands. It is comparatively easy of ascent, and its west side is nearly precipitous. Fort William, an old military town at its western base, is on the sea coast. Some years ago this mountain was considered exceptionally advantageous for observations at its summit and base for the pressure and temperature of the air, and for the direction of the wind at a difference of above 4000 feet level. Accordingly Mr. Wragge made arrangements for observations from June to October during the three years 1881—83. Since that time improvements were made in the buildings on the summit; telegraphic communication was made between the summit and base of the mountain; and Mr. Ormond

and others have for the past seven years made very careful observations during the whole year.

Dr. Alexander Buchan, the secretary of the Scottish Meteorological Society, has recently published in the Journal of the Society an outline of the observations made at the Ben Nevis Observatory and at Fort William during that period, and again in the "Transactions of the Royal Society of Edinburgh." From this account we find that for that period the mean barometric pressure at the height of 4407 feet (the top of the Ben) is 25·294 inches, and that the mean barometric pressure at sea level (Fort William) is 29·856 inches, the difference being 4·562 inches, or about an inch to the 1000 feet of difference of level. The difference reaches the maximum of 4·641 inches in February, and the minimum of 4·484 in July.

The mean temperatures at the top and bottom are 30·9° and 46·8° Fahr. respectively, the difference for 4407 feet of altitude being 15·9°. The difference reaches the maximum of 18·5° in April, and the minimum of 13·9° in January. The absolutely highest temperature at the Observatory was 67·0°, on June 24th, 1887, and the lowest, 6·4°, on February 10th, 1889.

The mean annual rainfall at the Observatory has been 140·17 inches; and at the base 78·19 inches; or 61·98 inches less at the base than at the top of the Ben.

The direction of the winds on the Ben indicates a well-marked diurnal variation. From 8 a.m. to 8 a.m. northerly winds (strength $2\frac{1}{2}$ miles an hour) prevail, whereas from 11 a.m. to 2 p.m., southerly winds (a little stronger) are in the ascendant. The coldest wind is from the north-east and the warmest from the south.

The electrical phenomenon, called St. Elmo's Fire, is often observed on the Ben, especially during the winter months. The weather which precedes, accompanies, and follows this phenomenon has quite marked characteristics. Stormy weather is called at the Observatory "St. Elmo's weather," so peculiar is it. In almost every case another cyclone, with its spell of bad weather, follows the particular cyclone in which St. Elmo's Fire is observed. Seventy per cent. of the thunderstorms occur from September to February, being very rare in summer—the very reverse of what occurs in the east of Scotland. But at Fort William summer thunderstorms are twice as frequent as at the Observatory, suggesting that a considerable number must be below the summit. The winter thunderstorms prevail at night; the reverse is the case in summer.

Professor C. Michie Smith has shown that, on the edge of a dissolving mist, the potential is lower than the average, but higher on the edge of a condensing mist. This is corroborated by the observations on Ben Nevis. When the top of the Ben becomes clear for a short time, a strong current comes up the telegraph wire from the base to the summit. But as soon as the summit is again mist-clad, the current is reversed. During a fall of rain the current nearly always passes down the wire; and in a sudden shower this current is very strong. When the rain stops the current passes upwards again.

Some very curious results are given about the enumeration of the dust-particles of the air, by means of the ingenious apparatus invented by Mr. John Aitken, of Falkirk. This apparatus we described in the October number of Knowledge last year. On 31st March of last year, at 4.30 p.m., the summit of the Ben was clear, and the number of dust-particles per cubic inch was 46,400, but shortly afterwards a thickness was observed approaching from the south-west, which by 6 p.m. reached the Observatory, and the dust-particles rose to 214,400 per cubic inch—the maximum observed since. On June 15th the number fell from 15,600 at midnight to 840 at 10.30 a.m.

But the observations on the 20th July were exceptionally remarkable. At Fort William the thermometer remained constant at 55° from 9 p.m. till 4 a.m. next day. But at the top there was a most marked variation of temperature. At 10 p.m. the wind suddenly veered from south-west to north, increasing to 40 miles an hour, and the temperature rose from 41° to 47°, and soon after to 49·2°. Ten observations were made with Aitken's dust-enumerator, between 2 and 3 a.m., and the extraordinarily low mean of only 84 dust-particles in the cubic inch was registered. From our last notice it will be found that 3500 per cubic inch is the lowest figure ascertained by Mr. Aitken, and that was in Switzerland. The peculiarity of this minimum register on the Ben is thus accounted for. A warm highly-saturated north wind was blowing out of the cyclone, which lay to the northward; whilst the sea-level wind, which was south-west, was blowing in upon the same cyclone. It is evident, then, that there is an intimate relationship between the number of dust-particles and the cyclones and anti-cyclones over North-Western Europe at the same time.

Halos, coronæ, fog-bows, glories, and other optical phenomena hold a prominent place among the observations on the Ben. But the most laborious investigation has been the determination of the rate of diminution of temperature with height, and the rate of the diminution of pressure for the different air-temperatures and sea-level pressures that occur.

BIRDS AND BERRIES.

By the Rev. Alex. S. Wilson, M.A., B.Sc.

(*Continued from page* 132.)

THERE are a few cases in which fruits though not succulent appear to depend on birds for the dispersion of their seeds. The snake-nut of Demerara (*Ophiocaryon paradoxum*) is so called on account of its peculiar coiled embryo presenting a striking resemblance to a small snake. The likeness is so marked that when the egg-like capsule is opened, one involuntarily starts back from the supposed reptile. It would seem that the imitation here is intended as a deception; for if a bird seizes the seed under the impression that it has got a snake, and after carrying it some distance discovers its mistake and lets it drop, then the object of the plant—dissemination—has been attained, and that without any outlay in the shape of succulent pulp or saccharine matter. In like manner the pod of *Scorpiurus subvillosa* has a curious resemblance to a centipede, and that of *S. vermiculata* to a worm or caterpillar. The long hanging pods of *Trichosanthes anguina*, as its name indicates, look very much like snakes. *Biserrula pelecinus* resembles a centipede. According to Lubbock, the seeds of *Abrus precatorius*, *Martynia diandra*, *Jatropha* and *Ricinus* mimic beetles, while several lupines have seeds resembling spiders.

The advantage of the mimicry in the rosary bean (*Abrus*) is easily understood. The beans are bright scarlet with a black, glossy patch. When the pod dehisces they are exposed to view and attract, we shall suppose, an insectivorous bird which mistakes them for a particular kind of beetle. After carrying the bean some distance the bird discovers its error, drops the seed, and thus gratuitously accomplishes the dissemination of *Abrus*. The seeds of *Clerodendron* also appear to be mimetic, and remind one somewhat of the rosary bean. Possibly this explanation also applies to the common cow-wheat, the

seed of which has a marked resemblance to the larva of an insect. The black shining seeds of a large number of plants, of columbine among others, might easily be mistaken for minute beetles, and the similarity may be of advantage in the manner indicated.

The fertilization of flowers and the dispersion of seeds are, of course, services unconsciously rendered so far as the insects and birds are concerned. There is the exceptional case of the Yucca moth, which deliberately pollinates the flowers on the seeds of which its larvæ feed. To this there would appear to be a curious parallel; for it is alleged that in Guatemala a bird has the remarkable habit of picking holes in the bark of a certain tree, and depositing therein the seeds of a parasitic plant on the berries of which it feeds.

Dispersion through the agency of birds is attended with certain advantages. The necessity for dispersion appears to be common to all plants; but this mode affords facilities for the transport of seeds across mountain ranges and arms of the sea, such as would prove effectual barriers to wind-borne seeds unless those of infinitesimally small dimensions. Birds are more likely to deliver the seeds in localities corresponding to the habitats of the plants. The maceration of the seeds in the bird's stomach in some cases appears to facilitate germination. This mode of dispersion is also preferable to wind agency where the number of individuals composing the plant species is limited, since fewer seeds will be lost or destroyed.

It is not very easy to account for the origin of these special provisions favouring dispersion by birds. The colours and sweet tastes of fruits as well as certain properties of the seeds might, no doubt, be referred to variation and natural selection. Possibly these may have arisen very much in the way that Darwin supposed the adaptation of flowers to insects to have been brought about. The pollen of primitive wind-fertilized flowers might, he thought, at first induce insects to visit them. The presence of nectar he explained as due in the first instance to the accidental appearance within the flower whorls of a sweet secretion occasionally exuded from various parts of plants, such as from the leaves of the common laurel and on the stipules of some of the Leguminosæ. Flowers which offered such attraction would be most frequented, and from being oftener crossed would give rise to more numerous and more vigorous seeds. Their descendants would inherit these peculiarities in a still higher degree. Colour and perfume would now come to be of service as additional attractions, the deepening of the flower-tubes in order to reserve the nectar for special visitors would follow, while corresponding modifications in the proboscis and other organs of those insects most dependent on the flowers might be expected to take place. In this way Darwin conceived it possible that in process of time the innumerable and wonderful contrivances for effecting the cross-fertilization of flowers through insect agency might have been called into existence. More recently Henslow has endeavoured to account for such peculiarities in flowers as the colour of the petals, their markings, the secretion of nectar, irritability of certain parts, coronas, spurs, &c., on the theory that they have been called forth as the result of a localized flow of nutriment induced through irritation caused by insects in visiting the flowers.

Neither of these explanations appears fully to meet the difficulty presented by fruits adapted to birds. In berries the softening of the fruit appears to have gone on simultaneously with the hardening of the seeds. In drupes the outer layer of the pericarp has grown soft while the inner layer has at the same time become indurated. It is by no means obvious how this differentiation of tissues could have originated. If we might hazard a conjecture, it would be that succulent fruits are related to those having an elastic pericarp which splits and forcibly ejects the seeds within The latter we take to represent a more primitive type. Hygroscopic fruits which in drying contract and suddenly explode, scattering their seeds in all directions, are not uncommon. Hygroscopic agency is indeed very generally employed as a means of dispersion; we find it adopted in all classes of plants. The twisting of the pods of the broom and the lotus, the spreading of the plumes composing the thistledown, and many similar phenomena, result from slight differences of adjoining tissues which cause them to dry at different rates. A piece of unseasoned timber warps in the same way because the green sap-wood on the one side dries more rapidly than the heart-wood on the other. The turgescence of certain tissues producing tension and sudden rupture accounts for the power of the mortar-fungus to project its spores. By this means some fungi literally bespatter with their sticky spores the leaves and stems of surrounding plants. The squirting cucumber when ripe breaks away from its stalk, and, by the forcible contraction of its walls as well as by the pressure of fluid within, the seeds along with the watery contents are shot out as from a syringe.

Better known examples of elasticity are the fruits of the hairy cress and the balsam. If these ripe fruits be touched the valves or carpels suddenly curl up and the seeds are thrown out all around.

On the assumption that birds at first simply fed on seeds, and that certain fruits and seeds already showed a tendency to become differentiated into an external soft and an internal hard layer, possibly as a means of scattering the ripe seeds by hygroscopic action, it is not difficult to see how there would be initiated a course of variation and natural selection which, by accentuating the difference between the two layers, would ultimately secure the complete protection of the seeds, and at the same time provide an inducement in the shape of sweet pulp sufficiently attractive to insure the services of the feathered tribes.

THE LONDON BASIN.

By Edward A. Martin.

To those who live in the suburbs of London, geology has a special interest, as, by its assistance, one is enabled to solve questions as to the composition and sanitary qualities of the various soils in the metropolitan area. Enquiries are often being made by persons about to choose a house, as to which neighbourhood is a healthy one to live in, and where one can find a good gravel soil. It is to be feared, however, that with the comparatively small area of gravel in the suburbs of London, only a few can choose such sites, and many have to put up with a clay soil. In that case, a house on a hill, or on rising ground, is preferable to one in a valley, or on flat ground, whilst the chalk hills which almost completely surround London would be found to afford a far better site than any of the London formations. But in London, with the exception of a very small district in the south-east, the chalk does not appear at the surface at all, being regularly covered by one or more formations belonging to the Eocene age, of which representatives are occasionally found in the South of England, *e.g.*, at Newhaven, Seaford, Furze Hill, Brighton, and in Hampshire. The chalk, as it approaches London from the south, most aggravatingly

sinks beneath the surface at a line joining the towns of Epsom, Sutton, Croydon, Orpington, and Sevenoaks, and to such a depth that, at the spot where a shaft was sunk by the Southwark and Vauxhall Water Company at Streatham a year or two ago, the chalk was only arrived at after traversing 241 feet of tertiary beds of clay, gravel, and sand. When, however, we pass beyond the northernmost limits of London, we again find the chalk immediately beneath our feet, cropping out from beneath these tertiary beds, at a line joining the towns of Watford, Rickmansworth, Beaconsfield, Marlow, Maidenhead, on to Reading and Hungerford, and forming the long southern slopes of the Chiltern Hills.

Thus we see that the whole of London, and the beds on which it is built, are held in the hollow of a trough in the chalk, the hills forming a natural boundary both north and south.

The beds above the chalk may be classified as follows:*—

1. {Made Earth, Alluvium.	3. London Clay.
	4. Oldhaven (Pebble) Beds.
2. {Brick Earth, Gravel and Sand.	5. Woolwich & Reading Beds.
	6. Thanet Sands.

A detailed sketch of each of these is scarcely called for here; a few characteristics, however, and the places where they can be seen may be of interest.

The Thanet Sands (6) are one of the most well-marked divisions of the tertiary strata. They attain their greatest thickness on the north-east coast of Kent, being 90 feet thick in the Isle of Thanet, from which they take their name. As we approach London in a westerly direction the bed gradually thins out, so that when we reach the Bank of England it is only 40 feet thick, and at Ealing, to the west of London, it has but a thickness of eight feet. The materials of which the bed is composed have a special characteristic attaching to them, and one which serves to show, to some extent, the source from whence the sand was derived before being laid down by the sea which once covered them. Under a microscope the particles of sand are ascertained to be of a regular crystalline form, altogether unlike the rounded grains of sands of which, for instance, the Brighton sands are composed. Now in Belgium there is a wide extent of country, the surface of which is composed of primary crystalline rocks, containing a large proportion of quartz, which is exactly the same as sand and flint in its chemical composition. This fact, together with the fact stated above, that the sands are thickest in the east and thin out to the west, serves to show that the sea denuded the crystalline rocks and washed the quartz westward, laying it down where we now see it, but only transporting the material in diminishing quantities to the west, the beds altogether dying out beyond Richmond. There are some sand pits at Charlton, near Woolwich, where it has a thickness of some 50 feet. Large quantities are there quarried and shipped as ballast by vessels going down the Thames. The vertical cliff caused by these quarrying operations shows us the topmast layer of the chalk at its base, whilst between the two is a thin layer, perhaps six inches thick, of flints. This layer is no doubt owing to the soft chalk having been washed away, the heavier flints being left behind by the water which denuded the chalk.

At Charlton the beds known as the Woolwich series (5) are also well developed. Similarly they are to be seen in full force at Castle Cliff, Newhaven, and at Seaford. The most remarkable feature about these beds is that they include layer above layer of shells, packed tightly together in a matrix of clay. When a mass of this is dried it bears a close resemblance to the shell-marble found in the Weald, and known as Sussex or Petworth marble. Much of the shell-sand used largely in London for spreading over garden-paths is obtained from these beds.

The Oldhaven Beds, next to be mentioned, are recognisable at once in the neighbourhood of London. In a matrix of clayey sand are contained large quantities of rounded pebbles not larger than a hen's egg, and generally smaller. These pebbles are noticed in large numbers in Greenwich Park. Blackheath itself sometimes gives its name to the series, whilst those who have visited Croham Hurst, to the south of Croydon, cannot but have noticed the quantities of pebbles which are trodden under foot.

All these formations, however, sink into insignificance beside the deposit of London Clay (3), which, in some places, is as much as 90 feet thick. In the London Basin it covers a great part of the surface, and it is also to be found in full force in Hampshire, extending beyond the Solent into the Isle of Wight. Looking at a geological map of the country one cannot help being struck by a conviction that these deposits were once continuous with each other, and that the whole of the area between Hampshire and the Thames has since been so completely washed away that now not a trace is to be found in that part of the country. The character of the fossils which the London Clay affords, at once point it out to have been deposited in a sea perhaps quite as deep as that which in a previous age had laid down the chalk. Most of the low hills around London are formed of this clay, such as Shooter's Hill, the Sydenham Hills, Primrose Hill, &c. The London Clay is a very stiff clay, and is impervious to water, consequently the surface is always more or less damp, although the effects of this are greatly modified in a large part of South London, owing to a subsequent deposition of gravel above it.

After the London Clay had been gradually accumulating for many ages beneath the ocean, the bed of the sea came to be gradually upheaved, until at last it appeared as dry land, the greater part of what are now the British Isles probably partaking in the upheaval. Thus, during the Miocene age which followed, no deposits were laid down in the neighbourhood of London, although during the succeeding Pliocene age the coast-line again approached sufficiently near to allow of the deposition by the sea of those beds known on the Norfolk and Suffolk coasts as the Coralline and Red Crags. A gradual declension of climatal temperature had been going on since the tropical times of the London Clay, through the sub-tropical Miocene age, and the temperate Pliocene era, until now at the ushering in of Pleistocene times, the climate was not far short of arctic, and indeed the country, as it then was, soon became covered by an extensive ice-sheet, and glaciers came sliding down from the higher grounds bringing with them the rocks of their place of origin, and depositing their burdens as they melted in places far removed from the land of their birth.

In the North of England the result has been that thick banks of clay known as "boulder clay" and "till" have been formed, whilst imbedded in them have been found a few species of shells of a distinctly arctic character, and such as are not now found on the English coasts at all. In the north of London, on the hills of Hampstead and Highgate, a capping of this boulder clay is to be found, the valley of the Thames being a rough boundary corresponding to the southernmost edge of the sphere of glacial influence.

At last the glacial epoch passed away, and with the melting of the ice-sheet the land became raised above the level of the sea. The Thames, charged with an increased

* After Whitaker.

volume of water, cut its way through the beds which surrounded it, and, deriving large quantities of flints from the existing Eocene pebble beds, it proceeded to scatter them along its banks, and to deposit them in the then lower reaches of the river, thus giving rise to those wide tracts of "gravel and sand" (2) which cover so large an area in South London. These gravel deposits must not be confounded with certain gravel beaches and terraces which occur in the north of London and which owe their origin to the glacial conditions already referred to as also giving rise to the boulder clays.

In approaching London from the east, as soon as we get clear of a line drawn from Greenwich through Lewisham, and extended southward, we leave all the outcrops of the London tertiaries behind, with the exception of one, viz., the London Clay. This important formation, together with, in some parts, the river gravels, constitute almost the whole of South London between the imaginary line we have drawn, and a western boundary which we may fix as far west as Kingston and Wimbledon. The eastern part of Wimbledon Common is London Clay, and on the west the gravels are well developed. Tooting Common is situated on the clay, North Brixton and Clapham are mostly built upon gravel, although in the latter place the clay shows itself largely at Clapham Park. Sydenham, the Crystal Palace, and Forest Hill are built upon clay, but both north and south of the Palace there are two patches of gravel on the summit of the hills. Think of the time when the river was sufficiently broad to deposit this gravel, about six miles from the present river! Continuing eastward, we find a thick bed of gravel following the valley of the River Ravensbourne, identical in direction with the Lewisham Road, and reaching to the south of Bromley.

North of these places, and between them and the river, the surface consists of "gravel and sand," except of course in the immediate vicinity of the river. This would seem to show that the river, previous to laying down the gravel, destroyed a great part of the tertiaries, leaving only a part of the London Clay exposed, and then with the denuded fragments deposited the pebbles in the form of gravel.

Thus the work of destruction and denudation went on side by side with that of construction, the two actions to some extent counterbalancing one another.

It is a striking fact that the next formation—that of the Alluvium (1)—although found to so great an extent below London Bridge, is scarcely found at all above it, and this is, indeed, very likely to have been the cause of the choice of site on which the city was built. Over a large part of Bermondsey there appears this thick bed of river mud, whilst in the bed of the river, eastward from London Bridge, an important fault appears to have occurred, so that the strata on the north of the river have sunk down to a lower level than those on the south. The result of this fault was that the river spread itself over a wide tract of land on the north, and in prehistoric times deposited alluvium wherever it went. Even now the level is considerably lower than that on the south, and consists principally of wide stretches of marsh land.

THE FACE OF THE SKY FOR NOVEMBER.

By Herbert Sadler, F.R.A.S.

There is no diminution in the increase of the number of solar spots and faculæ. The following are conveniently observable minima of some Algol-type variables (*cf.* "Face of the Sky" for October). U Cephei.—November 2nd, 0h. 11m. A.M.; November 6th, 11h. 50m. P.M.; November 11th, 11h. 30m. P.M.; November 16th, 11h. 10m. P.M.; November 21st, 10h. 50m. P.M.; November 26th, 10h. 29m. P.M. Algol.—November 2nd, 11h. 30m. P.M.; November 5th, 8h. 9m. P.M.; November 8th, 5h. 7m. P.M.; November 25th, 10h. 1m. P.M; November 28th, 6h. 49m. P.M. λ Tauri.—November 2nd, midnight; November 6th, 10h. 53m. P.M.; November 10th, 9h. 45m. P.M.; November 14th, 8h. 37m. P.M.; November 18th, 7h. 29m. P.M.; November 22nd, 6h. 23m. P.M.; November 26th, 5h. 15m. P.M.

With the exception of Jupiter and Neptune, none of the planets are well situated for observation by the amateur in November. Mercury is practically invisible as, though he sets on the last day of the month at 4h. 40m. P.M., or 46 minutes after the Sun, his tremendous southern declination ($25\frac{3}{4}°$) will preclude observation. The same may be said of Venus, setting as she does on the 30th at 4h. 55m. P.M., or 1h. 1m. after the Sun, with a southern declination of 24° 19′. Mars does not rise on the last day of the month till 3h. 39m. A.M, and Saturn not till 1h. 6m. A.M.

Jupiter is still a magnificent object in the evening sky, setting on the 1st at 1h. 15m. A.M., with a southern declination of 9° 48′, and an apparent equatorial diameter of $44\frac{1}{2}''$. On the last day of the month he sets at 11h. 26m. P.M., with a southern declination of 9° 15′, and an apparent equatorial diameter of $40\frac{1}{4}''$. The phasis on the preceding limb of the planet is now very perceptible, amounting at the end of the month to $\frac{4}{10}$ of a second of arc. The following phenomena of the satellites occur before midnight, while Jupiter is more than 8° above, and the Sun 8° below, the horizon. On the 1st, an eclipse reappearance of the first satellite at 7h. 37m. 53s. On the 2nd an occultation disappearance of the second satellite at 7h. 39m. P.M. On the 3rd an eclipse reappearance of the third satellite at 5h. 27m. 25s. P.M. On the 4th, a transit egress of the second satellite at 5h. 38m. P.M., and of its shadow at 8h. 2m. P.M. On the 6th, a transit ingress of the third satellite at 11h. 10m. P.M., and an occultation disappearance of the first satellite at 11h. 34m. P.M. On the 7th, a transit ingress of the first satellite at 8h. 42m. P.M., of its shadow at 9h. 57m. P.M., and a transit egress of the satellite at 11h. 1m. P.M. On the 8th, an occultation disappearance of the first satellite at 6h. 2m. P.M., and an eclipse reappearance of the satellite at 9h. 33m. 32s. P.M. A transit egress of the first satellite at 5h. 29m. P.M. on the 9th; a transit egress of its shadow at 6h. 44m. P.M.; a transit ingress of the shadow of the fourth satellite at 7h. 27m. P.M.; an occultation disappearance of the second satellite at 10h. 7m. P.M.; a transit egress of the shadow of the fourth satellite at 11h. 6m. P.M. On the 10th, an eclipse disappearance of the third satellite at 6h. 21m. 17s. P.M., and a reappearance at 9h. 28m. 55s. P.M. On the 11th, a transit ingress of the second satellite at 5h. 15m. P.M., a transit ingress of its shadow at 7h. 50m. P.M.; a transit egress of the satellite at 8h. 8m. P.M., and of its shadow at 10h. 40m. P.M. On the 14th, a transit ingress of the first satellite at 10h. 34m. P.M. On the 15th, an occultation disappearance of the first satellite at 7h. 55m. P.M. On the 16th, a transit ingress of the first satellite at 5h. 3m. P.M., of its shadow at 6h. 22m. P.M.; a transit egress of the satellite at 7h. 21m. P.M., and of its shadow at 8h. 40m. P.M. On the 17th, an eclipse reappearance of the first satellite at 5h. 58m. 3s. P.M.; an occultation reappearance of the first satellite at 6h. 23m. P.M.; an occultation reappearance of the third satellite at 8h. 21m. P.M.; an eclipse disappearance of the third satellite at 10h. 23m. 32s. On the 18th, a transit ingress of the second satellite at 7h. 47m. P.M., of its shadow at 10h. 28m. P.M.; and a transit egress of the satellite at 10h. 41m. P.M. On the 20th, an eclipse reappearance of the second satellite at 7h. 23m. 26s. P.M.

On the 21st, a ninth magnitude star will be situated a few seconds of arc north of the planet, actual conjunction with the centre taking place at about 5h. P.M. On the 22nd, a transit ingress of the first satellite at 6h. 56m. P.M., of its shadow at 8h. 18m. P.M.; a transit egress of the satellite at 9h. 15m. P.M., and of its shadow at 10h. 35m. P.M. On the 24th, an eclipse reappearance of the first satellite at 7h. 53m. 43s. P.M.; and an occultation disappearance of the third satellite at 8h. 48m. P.M. On the 25th, a transit egress of the shadow of the first satellite at 5h. 4m. P.M.; and a transit ingress of the second satellite at 10h. 22m. P.M. On the 26th, a transit egress of the shadow of the fourth satellite at 5h. 18m. P.M. On the 27th, an eclipse reappearance of the second satellite at 10h. 0m. 45s. P.M. On the 28th, a transit egress of the shadow of the third satellite at 7h. 40m. P.M. On the 29th, a transit egress of the shadow of the second satellite at 5h. 14m. P.M. On the 30th, a transit ingress of the first satellite at 8h. 52m. P.M., and of its shadow at 10h. 13m. P.M. Jupiter is stationary on the 3rd, and after that pursues a short direct path in Aquarius, but without approaching any naked eye star.

Neptune is admirably situated for observation, coming into opposition with the Sun on the last day of the month at a distance from the earth of about $2680\frac{1}{2}$ millions of miles. He rises on the 1st at 5h. 53m. P.M., with a northern declination of 20° 6′ and an apparent diameter of 2·7″. On the 30th he rises at 3h. 51m. P.M., with a northern declination of 19° 59′. He describes a short retrograde path in Taurus, to the N.W. of ε Tauri. A map of the stars down to $10\frac{1}{2}$ magnitude near his path will be found in the *English Mechanic* for October 16th, 1891.

November is a very favourable month for shooting stars. The most marked displays are the *Leonids* on November 13th and 14th, the radiant point being in R.A. 10h. 0m., northern declination 23°. The radiant point rises at about 10h. 15m. P.M. The *Andromedes* occur on the 27th, the radiant point being in R.A. 1h. 40m., northern declination 43°.

The Moon is new at 6h. 33m. P.M. on the 1st; enters her first quarter at 8h. 46m. A.M. on the 9th; is full at 0h. 16m. A.M. on the 16th; and enters her last quarter at 8h. 26m. A.M. on the 23rd. She is in perigee at 1·2h. A.M. on the 14th (distance from the earth, 225,015 miles), and in apogee at 8·8h. P.M. on the 25th (distance from the earth, 251,690 miles). The greatest eastern libration is at 3h. 6m. A.M. on the 7th, and the greatest western at 7h. 16m. P.M. on the 9th. There will be a very fine total eclipse of the Moon on the night of the 15th and early morning of the 16th. The first contact with the penumbra is at 9h. 37m. P.M. on the 15th; with the shadow (at 55° from the northernmost point of the Moon's limb towards the east, direct image) at 10h. 35m. P.M.; beginning of total phase, 11h. 37m. P.M. on the 15th; middle of the eclipse, 0h. 19m. A.M. on the 16th; end of total phase, 1h. 0m. A.M. on the 16th; last contact with the shadow (at 95° from the northernmost point towards the west) at 2h. 3m. A.M. on the 16th; last contact with the penumbra at 3h. 1m. A.M. on the 16th. The magnitude of the eclipse (Moon's diameter = 1), 1·386.

Chess Column.

By C. D. Locock, B.A.Oxon.

All communications for this column should be addressed to the "Chess Editor, *Knowledge Office*," and posted before the 10th of each month.

Solution of Problem No. 4 (*by J. Oehquist*) 1. Q to R8, K to Q3; 2. Kt to B7 ch. etc., anything else; 2. Kt to Q7 ch., etc. The above was a prize problem in a recent tournament of the Helsingfors Chess Club.

Correct Solutions from:—K, Alpha, H. S. Brandreth, M. B. (Jesmond), C. T. Blanshard, C. S., Giu. Pianissimo, J. G. Ellis, T. A. Earl, W. T. Hurley, W. E. B., R. W. Houghton, Betula, G. F., R. T. M., A. Rutherford, F. R., J. Taylor, R. W. Compton, and T.—(20 correct, 1 incorrect.)

T.—Your solution is counted correct, though it is barely legible. Could you not rectify this in future?

C. T. Blanshard.—Many thanks; but got your letter too late to make use of ticket.

G. F.—The Centre Counter Gambit is undoubtedly the best defence when receiving the odds of QKt.

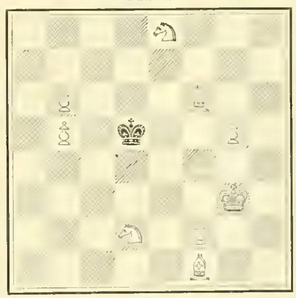
C. S.—The revised position is a great improvement, but there seems to be no mate after 1. . . B to Ksq Should be glad to insert when sound.

J. Taylor.—No mistake was noticed. 2. Kt to B3 is equally good after 1 . . . P to Kt3.

PROBLEM (No. 5).

By D. R.

Black.



White.

White to play, and mate in three moves.

The attention of competitors is called to the following amended rule:—"Should a problem admit of more than one key-move, *two* additional points will be awarded for each discovery of such key-move in the case of two-move problems, and *four* additional points in the case of other problems. The same number of marks will be deducted should any such claim prove incorrect."

Leading Solvers' Scores.

Alpha	22	R. T. M.	22
W. E. B.	22	A. Rutherford	22
W. T. Hurley	22	T.	22
K.	22	J. Taylor	22
Giu. Pianissimo	22	Betula	18
T. A. Earl	22	T. E. Kerrigan	14
F. R.	22	E. B.	14
R. W. Houghton	22	J. Landau	14
G. F.	22	J. G. Ellis	14
C. S.	22	White Knight	14
M. B. (Jesmond)	22	H. S. Brandreth	11
C. T. Blanshard	22		

Mr. T. E. Kerrigan has unfortunately been compelled to retire owing to illness.

CHESS INTELLIGENCE.

Another tournament is in progress at Simpson's Divan, 101, Strand. The players are the same as in the previous competition, with the exception that Mr. Rolland takes the place of Mr. Lee. Messrs. Tinsley and Loman have made the best start. The former did not sustain his reputation in the former tournament, which was won by Mr. Loman. The latter player has recently won the first prize in the National Tournament at Amsterdam.

Mr. Blackburne played 8 games blindfold at the City of London Club, on October 5th, winning 5, drawing 2, and losing 1. Playing simultaneously at the same club on October 9th, he won 16, drew 3, and lost 1.

For the "*Chess Player's Annual and Club Directory*, 1892," the authors, Mr. and Mrs. T. B. Rowland, 11, Victoria Terrace, Clontarf, Dublin, invite the following particulars of chess clubs:—Town, club name, year established, place of meeting, days, hours, number of members, annual subscription, laws, president, hon. secretary's name and address. Printed forms will be had on application.

Game played at the late Oxford meeting of the Counties' Chess Association.

[Hungarian Defence.]

WHITE (H. W. Trenchard).	BLACK (E. Thorold).
1. P to K4	1. P to K4
2. Kt to KB3	2. Kt to QB3
3. B to B4	3. B to K2
4. P to Q4	4. P × P
5. Kt × P (*a*)	5. Kt to K4 (?)
6. B to K2 (*b*)	6. P to Q3
7. P to KB4	7. Kt to Kt3
8. Castles	8. Kt to B3
9. QKt to B3	9. P to KR4 (?) (*c*)
10. P to KR3 (*d*)	10. P to B3
11. B to K3	11. Q to B2
12. Q to Ksq	12. B to Q2
13. Kt to B3 (*e*)	13. P to R5 (*f*)
14. Kt to Kt5	14. Kt to R4
15. B × Kt	15. R × B
16. Q to K2	16. R to R3 (*g*)
17. QR to Ksq (*h*)	17. Q to R4
18. Kt to B3 (*i*)	18. R to Rsq
19. P to B5 (?)	19. Kt to K4
20. Q to B2	20. Castles (QR) (*j*)
21. B × P	21. Kt × Ktch
22. P × Kt	22. K to B2
23. P to Kt4 (!)	23. Q to K4 (*k*)
24. Kt to K2	24. P to B4 (*l*)
25. P to KB4 (!)	25. Q × KP
26. Kt to B3	26. Q to B5 (*m*)
27. Q to Q2 (!)	27. B to KB3
28. Kt to Q5ch	28. K to B3
29. P to Kt5ch	29. Q × P (*x*)
30. R to Ktsq	30. B to Q5 ch (!)
31. K to R2	31. Q to R5 (*n*)
32. R to Kt6ch!	32. K × Kt
33. P to B4ch (*o*)	33. K to K5
34. Q to KKt2ch	34. K × P
35. Q to Kt5ch	35. K to K5
36. Q to Q5ch	36. K to Q6
37. Q to B3ch	37. B to K6 (*p*)
38. R to Qsq ch	38. Q × R
39. Q × Qch, and wins	

NOTES.

(*a*) P to B3 is also good. Black cannot take the Pawn on account of the reply Q to Q5.

(*b*) Too defensive. There is nothing to fear from 6. B to Kt3, P to QB4?; 7. Kt to B5, P to B5; 8. Kt to Q6ch, etc.

(*c*) Black has a bad game, but this unseasonable attempt at counter-attack does not improve it. He would do better to Castle and retire his Knights.

(*d*) Partly with a view to his next move, partly to prevent B to Kt5, which would free Black's game a little. Black has now practically nothing to do.

(*e*) To prevent Black's castling (QR). It seems a pity, however, to move the Knight yet. He might play QR to Qsq, and if Black Castle (QR), then P to QKt4.

(*f*) An ingenious reply. White gains nothing by 14. P to B5?, Kt to K4; 15. Kt × P, Kt × P, etc.

(*g*) Much better retire all the way. *Vide* move 18.

(*h*) Not very intelligible. He should play Q to B2 first, at any rate, and decide afterwards where he wants the Rook. Some players would be tempted by 17. Kt × KBP, K × Kt; 18. P to B5, Kt to K4; 19. B × R, P × B; 20. Q to R5ch; but Black's two Bishops might eventually prove too strong.

(*i*) There is no necessity to retire. He might amend his last move by R to Qsq. This and his next move were probably made under pressure of the time-limit.

(*j*) There is no point in this sacrifice. He might play Kt × Kt, followed by B to B3, or B to Qsq.

(*k*) If 23. . . . Q × KtP, 24. R to Ktsq; winning the Queen or Mating. Mr. Trenchard on his next move rejects B to Kt6ch, which would leave him with R and Kt against two Bishops (*vide* March No.), while Black might get some counter-attack, beginning with P to KKt3.

(*l*) Here R to Rsq is certainly better. If then 25. P to QB4 (threatening B to Q4), P to QB4.

(*m*) Q to Q5. Either now or next move would obviously lose a piece.

(*x*) After 29. . . . K × P, 30. R to Kt sq ch, K to R3; White mates in five moves.

(*n*) If Q to B5, White mates in three moves.

(*o*) Very pretty. If Q × P, mate follows on the move; if K × P, in three.

(*p*) Black's moves are all forced. If 37. . . . K to Q7. 38. R to Kt2 ch!

Mr. Trenchard's play from the 23rd move is a fine exhibition of vigour and accuracy.

CONTENTS OF No. 72.

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CONTENTS.

BRITISH MOSSES.*

By the Rt. Hon. Lord Justice Fry, F.R.S., F.S.A., F.L.S.

LORD BACON thought that a Moss was "but a rudiment between putrefaction and a herb." Mr. Ruskin thought, and perhaps thinks (he is at war, he tells us, with the botanists), "that the pineapple is really a Moss." People popularly talk of Club-Mosses and Stag-Mosses. Now all these usages of the word may be useful to us when we begin to think about Mosses, if we will make the right use of them, *i.e.*, if we will absolutely reverse them. A Moss is not a rudiment between a putrefaction and a herb, but a delicately, exquisitely organized plant. No possible stretch of the conception of a Moss can make it include a pineapple any more than an elephant; and the stag and club-Mosses of popular speech belong to a group of plants quite different from the Mosses, and of a far higher organization.

What then is a Moss? This is a question not to be hastily answered, and will I think be best answered at the end and not at the beginning of this paper. If you are working deductively, your definitions may come at the beginning: but if by patient investigation into natural facts, beware of starting with definitions—they ought to be the ripest fruit of your longest labour.

Vegetable productions are commonly divided into two great groups: those which possess obvious blossoms, or Phanerogams, and those which possess no obvious blossoms, or Cryptogams. The Cryptogams are again divided into two great groups—those whose structure is built up of cells without regularly formed vessels, such as sea weeds, fungi and lichens, the cellular Cryptogams; and those which, like the ferns and the club-Mosses, possess, in addition to cells, regularly formed vessels; these are known as Vascular Cryptogams.

This brief explanation will be enough to enable the reader to learn from the following table, which is arranged in an ascending rank, something as to the position of the Mosses in the vegetable kingdom, and the principal groups into which they may be divided:—

TABLE A.

	Series.		Orders.	Examples.
Vascular Cryptogams				
Muscineæ	i. Musci.	Pleurocarpæ		Hypnum
		Acrocarpæ	Stegocarpæ	Polytrichum
			Cleistocarpæ	Phascum
		Anomaleæ	Schizocarpæ	Andræa
			Holocarpæ	Archidium
	ii. Sphagnaceæ			
	iii. Hepaticeæ.		Jungermanniaceæ	
			Marchantiaceæ	
Algæ, &c.				

From this table it will be gathered that the Mosses, using that word in its wide signification, stand at the head of the cellular cryptogams, and that above them are the vascular cryptogams, of which, as I have already said, the ferns are one of the best-known groups. From these vascular cryptogams the Mosses are, however, separated by a distance which Goebel has described as a chasm "the widest with which we are acquainted in the whole vegetable kingdom." Perhaps, however, at some future time it may be found that even over this gulf Nature has thrown some slender bridge.

From the table it will be further seen that the larger group of the Muscineæ divides itself into three principal smaller groups: the Hepaticeæ or liverworts, the Sphagnaceæ or turf Mosses, and the Musci or true Mosses—Urn-Mosses, as they have been called, from the form of their capsule. These three divisions the Germans conveniently name as Leber-Moose, Torf-Moose, and Laub-Moose.

Now I will ask the reader to look at the column under the word "Series." The Pleurocarpæ or Pleurocarpous Mosses are those which carry their capsules on stalks proceeding from the sides of the axis of growth; the Acrocarpæ or Acrocarpous Mosses are those which bear these capsules on the top of their axis of growth. This

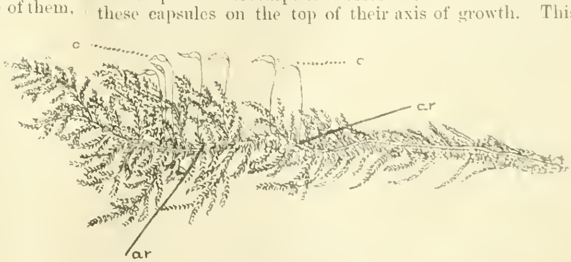


Fig. 1. Hypnum: a Pleurocarpous Moss, after Dillenius. *ar.* Position of the Archegones. *c c.* Capsules.

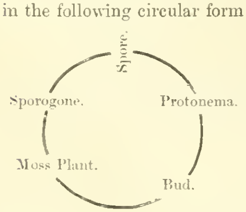
* This paper has grown out of a discourse at the Royal Institution, given by the author in January, 1891.

distinction will be readily understood by comparing Fig. 1, which is a Pleurocarpous Moss, with Figs. 2 and 3, which represent an Acrocarpous Moss; in the former it will be seen that the axis, or line of growth, is horizontal, that the plant, in short, grows along the ground, whilst in the latter the direction of growth is vertical. Again, in the former the capsules *c c* are seen carried on stalks originating from the principal stem, whilst in Fig. 2 the capsule *a* crowns the line of growth. This distinction in the mode of carrying the capsule is one of great importance in the classification of Mosses, and the student who desires to begin to learn them should pay early attention to it. Often it is perfectly easy of application, but intermediate forms occur which are puzzles, and go to show that the chasm between the two forms is bridged over in Nature.

FIG. 2.—Polytrichum: an Acrocarpous Moss Female Plant, after Dillenius. *ar.* Position of archegone. *s.* Seta. *a.* Capsule and appendages. *c* and *c*[1]. Capsule. *o.* Operculum. *cal.* Calyptra.

FIG. 3.—Polytrichum: Male Plant. After Dillenius. *a.* Male Blossom.

Life-History.—I propose now to trace the life-history of a Moss in its most complete course of life, and I shall then show how, in many cases, this course is abbreviated. It will be found that the full cycle of life may be indicated in the following circular form:—



so that, starting with a spore of one generation, and travelling to our right hand, we return to another spore which will give rise to a new circle of life.

(1) The spore is a simple cell; how produced we shall hereafter see. It is, I say, a simple cell, and not like the seed of a phanerogam, a highly complex organism. The spores are often seen to be emitted in vast numbers from the cases in which they are produced, and sometimes are brightly coloured—red, green, or yellow. Fig. 4 represents (highly magnified) the spore of a common Moss, the Funaria hygrometrica.

FIG. 4.—Spore of Funaria hygrometrica. After Schimper.

(2) From the spore proceeds the protonema, a line of cells, extending by transverse divisions, so that it comes to consist of single cells joined end to end to one another—an organism indistinguishable from the hypha of an Alga. At points this hypha throws off lateral branches, which are always of less diameter than the principal ones. There is thus produced a tangled mat of fibres, running on or near the surface of the ground, and often coloured by chlorophyll. This is the green stuff so often seen in flower-pots which have been allowed to get too damp. At points in the primary hypha cells begin to divide in a new fashion—not by transverse septa as before, but by septa differently inclined, so as to produce the rudiments of leaves; and the direction of growth changes from horizontal to vertical. Thus is formed (3) the bud, which by growth gives rise to (4) the Moss plant.

FIG. 5.—Spore with young Protonema. After Schimper.

This course of development is illustrated by Figs. 5 and 6. Fig. 5 shows at *a* the remains of the cell which has burst in emitting the hypha, or cellular projection to the right. Fig. 6 shows the same plant further advanced in

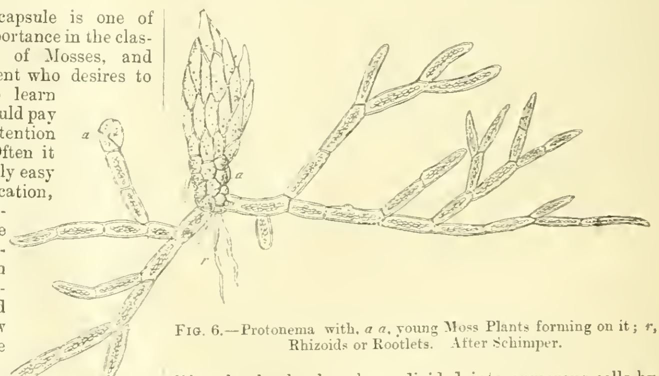


FIG. 6.—Protonema with *a a*, young Moss Plants forming on it; *r*, Rhizoids or Rootlets. After Schimper.

life; the hypha has been divided into numerous cells by the transverse septa or walls; lateral branches have grown. Two letters *a* will be observed on the diagram. At the left hand *a* the divisions of the cells have assumed a new inclination so as to cut the cells into rudimentary leaves, and we have the first promise of the Moss plant. At the right hand *a* we have another Moss plant in a far more advanced stage, showing distinct traces of leaves, and having thrown out rootlets (*r*) downwards. The Moss plant when mature assumes generally, but not universally, a form referable to one or other of the two types already described, either the pleurocarpous form shown by Fig. 1 or the acrocarpous form shown in Fig. 2. This Moss plant is a structure of very considerable complexity, and often of great beauty of form. Sometimes it assumes the likeness of some of the smaller and more delicate ferns; but very rarely would it be taken for a flowering plant, even by a casual observer.

The Moss plant produces organs with two distinct functions, comparable the one to the pistil and ovary,

and the other to the stamens including the anthers of a flowering plant. The organ corresponding with the pistil is called the archegonium or archegone; the organs corresponding with the stamens the antheridia or antherids. The archegone is a flask-shaped organ, which ultimately produces a specialized cell, known as the oosphere, at the bottom of the flask, the neck of which is perforated by a canal. This organ is usually surrounded by circles of leaves, often larger and almost always different in form from the ordinary leaves of the Moss. The ordered arrangement of these leaves produces something like a flower, and is known as the perichætium, *i.e.*, the surroundings of the couch. If the reader will turn to Figs. 1 and 2, and note the letters *a r*, they will indicate the situation of the archegone before it gave rise to the capsule.

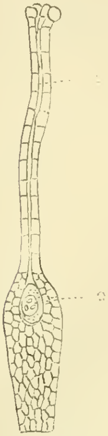


Fig. 7.—Archegone greatly magnified. *c.* Canal. *o.* Oosphere. After Berkeley.

Fig. 7 will show an archegone, with the canal, *c*, and the oosphere, *o*.

The male organs are known as antherids. Fig. 8 shows an antherid, a long bag-like cell, surrounded by filaments, sometimes club-shaped, called paraphyses. These are usually associated in groups, and surrounded by specialized leaves, often in the shape of a rosette, and when (as sometimes) they are highly coloured they present the aspect of small but beautiful flowers. Fig. 3 exhibits a male plant of one of our common Mosses, the Polytrichum, terminating in the rosette-shaped flower of a scarlet colour, composed of the antherids, the paraphyses, and the specialized leaves. The large beds of these short stiff male plants of Polytrichum, which may often be seen in the spring of the year, are objects of great, but, I fear, often neglected, beauty.

Fig. 8.—Antherid *a*, with Paraphyses, *p*. *az*, Escaping Antherizoids. After Berkeley.

The antherids burst and give out swarms of small bodies, known as antherizoids, consisting of roundish cells containing in the interior a spiral thread, which produces a rotatory movement in the containing cell. Fig. 9 represents such antherizoids. These little bodies find their way to the canals of the archegone, pass down it, and enter the oosphere, and so effect that union of two independent cells which produces fertilization.

Fig. 9. Antherizoids, showing spiral threads. After Schimper.

(To be continued.)

A GOSSIP ON GHOST-NAMES.

By Canon Isaac Taylor, M.A., LL.D., Litt.D.,

Author of "Words and Places," &c.

A GOOD many words have crept into our dictionaries which are not words at all, having arisen from uncorrected misprints, the blunders of scribes, or the mistakes of compositors in deciphering the illegible manuscripts of authors. Such words have been well designated by Professor Skeat as Ghost-words. But Professor Skeat has said nothing about what may be called Ghost-names, which are, perhaps, more numerous than Ghost-words, inasmuch as in a manuscript, however badly written, the context gives some clue to an undecipherable word, whereas in the case of a name there is no such aid. Hence we find on our maps not a few names which are properly not real names, but merely blunders which pass for names.

Not long ago I happened to be present at the birth of a Ghost-name. Crossing the Bay of Biscay from the south in one of the boats of the P. & O., a passenger inquired when we should pass Cape Quessant. Never having heard of such a cape, I asked him where it was. He took me into the smoking room, where a well-thumbed atlas, belonging to the ship, lay upon a table, and he pointed to the name of Cape Quessant at the extreme western corner of Brittany. An examination of the map led to the removal of a tiny speck of dirt at the bottom of the first letter of the name, and Cape Quessant reappeared as Cape Ouessant, the usual French spelling of the name, often written Ushant in English books.

Several Ghost-names have arisen in this way from misreadings of the manuscripts of classical writers. In Scotland we have three such names, those of the Hebrides, the Grampians, and Iona. The Western Isles of Scotland are called the Hebrides, a name which has been transferred by Captain Cook to the New Hebrides in the South Pacific. Much fruitless ingenuity has been expended in the attempt to discover the etymology of the name. The explanation is very simple. Before the introduction of the dot over the letter *i* in the eleventh century, the letters *ri*, in the Caroline Minuscule, resembled greatly the letter *u*. Two early editions of Pliny's "Natural History" were printed from a manuscript in which the name Hæ*bu*des appeared as Hæb*ri*des, and hence Hæbrides was accepted as the ancient name of the Western Isles. That the reading was erroneous is shown, not only by better manuscripts, but by a notice in Solinus, who speaks of the *Hebudes insulæ quinque numero*, and the islands are called Ebudæ by Ptolemy. The Ebudes were doubtless so called because they lie around the island of Ebuda, now Bute, which is the nearest to the mainland, and would therefore be the first to become known to the Romans.

The second Scotch Ghost-name is that of the Grampians, which is given to the backbone of Scotland, extending from Ben Nevis to Ben Lomond. The old and correct Gaelic name was "Drumalban," the *Dorsum Albaniæ* of Latin writers. This use of the name Grampians contains a double blunder. Tacitus, in his "Life of Agricola," chapter 29, describing the victory of the Romans over Galgacus, tells us that the Caledonians were posted on a hill, which in all the best manuscripts appears as Mons Graupius. In one manuscript of small value, this name Graupius appears as Grampius. The Scotch historian, Hector Boece, who died in 1536, was the first to transfer this misread name from the rising ground on which the battle was fought to the central ridge of Scotland. The blunder was perpetuated in the celebrated forgery published in 1747 by Dr. Bertram, with the title *De Situ Britanniæ*, professing to be the work of Richard of Cirencester, a monk of St. Peter's Abbey, Westminster, who died in 1400; Bertram having doubtless made use of the history of Boece in compiling his work. Till Professor Mayor's detection of the forgery, Richard of Cirencester was supposed to be one of the best authorities for early English geography, and the book was freely used by Gibbon, Lingard, and other writers. Hence the double blunder of transferring a misread name from a small hillock to the great mountain

chain of Scotland has become so firmly rooted that it seems impossible to alter the usage.

Too firmly established to be now displaced is the name of Iona, the little island on which St. Columba founded the monastery which was to be the mother church of Scotland, and from which Irish missionaries went forth to convert the heathen nations of England, Germany, and Switzerland. But this name Iona originated, as Dr. Reeves has proved, in the blunder of a copyist. The island was called I, Hii, Ia, or Iou, "the island," whence we have the Mediæval name I-colm-kill, the "Island of St. Columba's cell." Adamnan, in his "Life of St. Columba," speaks of Ioua Insula, using the adjectival Latinized form Ioua for Iou. Some copyist, mistaking, as he easily might do, the *u* for *n*, wrote Iona Insula for Ioua Insula, and hence the island now appears on every map as Iona.

There are many names on our maps which have arisen from natives not understanding the questions put to them by inquiring travellers. Asking the name of some conspicuous object, a mountain or a river, the native guide replied in his own language "I don't know," or "I don't understand you," phrases which have been forthwith jotted down on the map as the name of the mountain or the river. Thus the name Yucatan, discovered in 1517 by Hernandez de Cordoba, was long supposed to be the native designation of the country. The native name, however, is Maya, and Yucatan is evidently a Ghost-name. Now in the Maya language *tectican* means "I don't understand you," and *jucatan* means "What do you say?" Evidently the name Yucatan must have arisen from one of these answers, probably the latter, being given by the native who was questioned by Hernandez as to the name of the country.

The vast State of Texas, whose area is greater than that of France and England put together, also bears a Ghost-name of similar origin. When Father Damian visited the coast at the end of the 17th century he asked a chief of the native tribe of the Assinaes who they were. The chief, misunderstanding him, replied *texia*, a "good friend," which Father Damian supposed to be the tribal name, and hence the Assinaes came to be called the Texas Indians, and this imaginary tribe-name was adopted as the name of the territory.

The name of the great Canadian dominion is also believed to have originated in a misunderstood answer to a misunderstood question. When Cartier, the French explorer, first sailed up the St. Lawrence, it would seem that, stretching out his hand, he asked a native the name of the country. He replied "Canada," a name by which the country has since been known. We now know that *Kanata* is a Red Indian designation for a village, or collection of wigwams, and the native must have thought that Cartier had pointed to some group of huts, and had asked what it was called. Canada, therefore, is itself a Ghost-name. Or take the name of the great State of Indiana. It was so called because it had been a reservation for the Red Indians. The American aborigines acquired the name of Indians because Columbus, when he discovered the New World, imagined that he had reached some islands lying off the coast of India, which he called the "Antilles," a Spanish word, meaning the "islands in front," being supposed by him to be islands lying in front of India. Hayti he identified with Japan, and Cuba with China. Columbus died in the belief that all the lands he had discovered belonged to Asia; and the delusion long survived. Thus there is a village near Montreal called "La Chine" (China). It bears the name of a house so called, erected by La Salle in 1666, which he named "La Chine," in the belief that the Mississippi, which he was preparing to explore, flowed into the Pacific, and that it would be possible, by descending it, to reach China and Japan.

Even the name America may almost be called a Ghost-name, certainly so in the sense in which citizens of the United States call themselves "Americans." Columbus believed that some of the lands he had discovered formed a part of India, and hence they received the names of "India Major" (Greater India), or of "Indias Occidentales" (the West Indies), which still cleaves to the islands where Columbus first touched land in 1492. Five years later, in 1497, the Englishman John Cabot reached Newfoundland, which he called "Prima Vista," the land "first seen," and he then coasted southwards as far as Florida. Hence the name of Newfoundland, which he gave to the continent he had discovered, was long used in England to denote the whole of North America, till at length it was restricted to the land first reached by Cabot. In 1500 the Portuguese, under Cabral, reached South America, which was named "Terra da Santa Cruz" (the "Land of the Holy Cross"). A few years later South America acquired the name of "Terra do Brazil," the land of a dye-wood, *brazil*, so called because it produced the colour of glowing charcoal (*braza*). According to Amerigo Vespucci's own account, he sailed, in a subordinate capacity, between 1497 and 1504, with an expedition which discovered a small part of the coast near the mouth of the Orinoco. What part (if any) Amerigo Vespucci took in the discovery of the New World is still a matter of controversy. However, in a book on geography, published in 1507, the name of "Americi Terra" (the "Land of Americus") was proposed by Waldseemüller for that portion of the coast which Vespucci claimed to have visited, but at this time it was not known that North America, or, as it was then called, Newfoundland, belonged to the same continent—in fact, a strait is shown on early maps in place of the Isthmus of Panama. This form, America, is found on a map published in 1522, but the name seems to have been unknown to Girava, a Spaniard, who observes in his "Cosmographia," published in 1570, that India, or the "New World," was called by some persons "India Major" (Greater India), to distinguish it from "India Oriental," or "East India." The name of America, as a designation of the New World, seems to have become popular mainly owing to its adoption in the great atlas of Ortellius, published in 1570. Even in 1608, Acosta, in his "History of the Indies," prefers the old Spanish name of the Indies to the new term America. Thus it appears that for about a century the five names, Newfoundland, the Indies, Brazil, the New World, and America struggled for existence, the ultimate choice of the name America being largely due to the supposed fitness of a name analogous to those of the three continents of the Old World.

The name of Australia, the last of the continents to be discovered, also arose out of a strange misconception. The early geographers supposed that the two hemispheres must contain a nearly equal quantity of land, in order to prevent the world from overbalancing by reason of the greater weight of the Northern Hemisphere. Hence they placed on their maps a vast conjectural southern continent which they termed Terra Australis Incognita, the "undiscovered southern land." When at last Australia became known, the Terra Australis Incognita became Terra Australis, and it was only in 1814 that Flinders, in his book entitled "A Voyage to Terra Australis," modestly observes in a footnote: "Had I permitted myself any innovation upon the original term, it would have been to convert it into Australia, as being more agreeable to the ear, and an assimilation to the name of the other great portions of the earth." The suggestion of

Flinders has, however, happily been adopted, and is a more rational name than those of Europe, Asia and Africa, which originally denoted only three small plains: the plain round Thebes, the plain round Ephesus, and the plain round Carthage.

(*To be continued.*)

SOME PRACTICAL APPLICATIONS OF ELECTRICITY.

By J. J. Stewart (*formerly Demonstrator of Physics at University College, London*).

(*Continued from page* 175.)

III.—Arc Lamps.

About the year 1802, Sir Humphry Davy, by sending an electric current from a powerful voltaic battery of 2000 cells through two sticks of wood charcoal placed a short distance apart, obtained a brilliant discharge between the two charcoal points. The rush of Electricity produced a bright stream of light, shaped like a bow, in the interval between the ends of the charcoal, and hence the name of "Voltaic Arc" was given to it by Davy. Some years later he exhibited the effect before an audience at the Royal Institution. Of course, the soft charcoal was rapidly disintegrated, and from this cause, and also on account of the great expense at which it was produced, when the battery of cells was the only available means of generating the current, this first example of the electric light could not be applied to any practical or commercial use.

It was only when the introduction of dynamo machines rendered possible the production of powerful currents at comparatively small cost that there was any prospect of Electricity being used for purposes of illumination. Those to whom we owe the first production of the electric arc do not seem to have had much expectation that it would prove a general means of obtaining artificial light, and in a description of the voltaic arc, published so late as the year 1880, it is described as painfully, and even dangerously intense, and is said to dazzle rather than illuminate.

When a strong current of Electricity forces its way across a gap in a metallic wire which it is traversing, the air in the space between the ends of the conductor, opposing as it does a great resistance to the passage of the current, is raised to a very high temperature, minute particles of the metal of the wire are driven off, and these, with any dust which may be in the air, are raised to a white heat, and thus a luminous bridge is formed between the two broken ends of the wire. The heat generated in a conductor in a given time by the passage of a current of Electricity is proportional to the square of the current and to the resistance of the conductor. When the current remains the same the heat produced varies simply with the resistance. In the above case the resistance of the wire conveying the current is small, while that of the air gap is very great; thus there is little heat developed in the wire itself, but at the break in the circuit where the current passes through air the heat developed is very great, being sufficient to make white-hot the air and metallic vapour in its path. No metallic conductors would be durable enough to allow of a permanent arc being set up between them; it is only with an infusible substance such as carbon that this can be done. The source of the light in the electric arc is in the incandescent particles of carbon driven off from the carbon poles. The first step in the progress to the useful application of the arc was the employment of hard carbon, taken from the deposit which forms inside the gas retorts during the manufacture of coal gas. Pencils of this material employed instead of Davy's soft charcoal gave a much more permanent arc, but the light was still uncertain and liable to much flickering, owing to inequalities in the substance of the carbon.

The voltaic arc is not an example of disruptive discharge, as in the case of the spark from an ordinary electric machine or Leyden jar, but seems rather to be an instance of conduction, the air at the high temperature to which it is raised becoming a conductor of Electricity. Thus, also, when once the arc has been started between the carbon points, they may be removed to a greater distance apart without the disappearance of the arc. The passage of incandescent particles of carbon from one terminal to the other can be shown by throwing a magnified image of the heated points on to a screen by means of a lens. On observing the image thus produced particles are seen to be traversing the arc, sometimes in one direction and sometimes in the other, but mostly from the positive to the negative carbon. The positive carbon wears away twice as rapidly as the negative one. Its end becomes hollowed out into a crater-like cavity, while the negative carbon preserves its pointed appearance. When the carbon points are placed in a vacuum, this difference in behaviour is more marked. The image of the points projected on the screen will also show the appearance of round globules at the sides of the glowing carbons; these are due to melted portions of silica and other impurities in the carbon.

The voltaic arc excels, both in temperature and brightness, all other artificial sources of heat, and, by its means, some of the most refractory substances, which had resisted all other attempts to melt them, have been fused and some volatilized.

However, a large proportion of the rays emitted do not affect the eye as light, and thus a considerable part of the energy in the arc is wasted for the purpose to which it is to be applied, that of illumination. In fact, we as yet know of no artificial method of economically producing energy in the form of waves of light; a notable portion of the energy we get seems necessarily expended in generating the dark heat rays, and those ultra-violet rays which do not produce the effect of light to our eyes. The only really economical light known where nearly all the energy is obtained in luminous waves, is that of the humble spark of the glow-worm; in this the heat is negligibly small and the luminous part marvellously great.

The arc, like other conductors conveying currents, is acted on by magnets, and by using a powerful magnet the arc may be driven out to one side and made to take a pointed form like a blow-pipe flame.

One of the principal factors in the production of a good and steady light from the voltaic arc is the use of carbons of a compact and uniform structure. The production of such carbons is the object with many manufacturers, most of whom observe considerable secrecy as to the actual methods they employ. In one form of carbon the stick is pierced along its length to form a tube, which is afterwards closed at one end and filled up by a solution of certain materials containing in suspension a fine powder of the same sort as that which composes the original rod. This is driven in under high pressure, and has as its result the displacing of the gases which are contained in the carbon, and which it is important to remove. The hollowed carbon rod is in this way by degrees filled up, and at length a very compact sort of carbon is obtained.

As an example of the methods used to obtain a suitable carbon, the process employed in the manufacture of Carré's

carbons, which are amongst the best, may be mentioned. These carbons are made from the following ingredients: 15 parts of pure very finely powdered coke, 5 parts of calcined lamp black, with 7 to 8 parts of a syrup made from cane sugar and gum. This mixture is made into a paste with water, pressed, and then forced through a die which gives to the rods the form and size required; afterwards they are repeatedly baked at a high temperature. After one baking the rods are plunged into a hot and concentrated syrup of sugar, in which they are left some time, taken out and again immersed until they are thoroughly saturated with the liquid. After washing and drying, a similar process is gone through again until the carbons are as dense as is required. They are then dried for a prolonged period in stoves, the result being an excellent and tough form of carbon.

During the working of the lamp the two carbon rods gradually consume away, and the mechanism of the various forms of arc lamp is contrived to bring up and keep the carbon poles at the requisite distance from each other, so that a steady and unvarying arc may continue between them. As the positive carbon, as has been said, consumes away twice as fast as the other, it must be moved up towards the negative carbon with double its speed, and the distance between the carbon points must be kept approximately uniform. There are various devices in use for attaining this object, and without going into complete details, one of the forms of Crompton's lamp may be taken as a specimen. This is one of the examples which gives the best results and avoids the flickering, which is apt to be the great fault of arc lamps. In Crompton's apparatus, here described (which is one of his earlier forms, but may serve as an illustration of the general methods adopted), the weight of the upper carbon and its holder acts as a motive power, which sets a train of wheelwork in action, and causes the carbons to move towards each other in proportion as they are worn away by disintegration of the carbon points. The operation of "striking the arc" is the following:—The upper carbon descends through its own weight, touches the lower carbon, and the current passes through the circuit. In the circuit is an electro-magnet, and, as the current passes round it, this immediately attracts a plate of metal which has a spring attached to it, and this causes the train of clockwork, which was set in motion by the falling upper carbon, to set off in a reverse direction and raise the carbon again to a certain distance, thus forming the arc. When the arc has reached a suitable length and the current attained a certain strength, the spring attached to the armature of the electro magnet presses against a wheel in the clockwork and stops its motion. When the current becomes weaker owing to lengthening of the arc the electro-magnet also decreases in strength, and a spiral spring which is attached to its armature causes it to rise and leave the magnet, and this causes the stoppage of the clockwork and allows the carbons to come nearer together. As the length of the arc is constantly tending to increase as the carbons wear away, the clockwork is rarely at rest for more than a second or two at a time, but the ingenious device of the electro-magnet with its armature regulating the motion of the wheelwork insures automatic adjustment, and thus produces a satisfactory degree of steadiness. The regulation is self-acting, for the same current which produces the arc circulates round the coils of the electro-magnet, and the variations in the arc and the controlling magnet occur together. In other forms of regulating mechanism which differ in detail, the electro-magnet is placed in a shunt circuit, so that when the arc becomes too long and its resistance increases, more of the current goes round the shunt, strengthening the electro-magnet and causing it to act so as to produce the approach of the carbons.

Arc lamps are most suited for out-of-door illumination and for lighting wide areas. For indoor purposes the incandescent lamps are much preferable. The extent lit by these is more circumscribed and the light less intense, which is an advantage when they are to be used in houses. The applications of arc lamps to various purposes other than street-lighting are very numerous and increasingly so. Their use for lighthouse purposes, where the intensity and concentration of their light, as well as its space-penetrating power, renders them valuable, as also their application to photography, in which their richness in the chemical rays is very useful, may be mentioned. It is worthy of note that the immediate source of the light, viz., incandescent particles of carbon, is the same whether candles, oil-lamps, gas, or electric arc lamps are the means of illumination.

ON HUMAN PEDICULI.—I.

By E. A. BUTLER.

If occasional parasites, such as fleas and bugs—creatures which simply visit our bodies at intervals, and spend only a small proportion of their lives actually on our persons—excite repugnance and disgust, what can be said of the feelings with which we contemplate those hideous pests that make men's bodies their life-long home, born and bred thereon, generation after generation, living there and there alone, and, as units of life, almost, if not entirely unknown, apart from such association? And yet, though cleanly people nowadays hold them in such utter abhorrence that they can hardly be named in polite society, they were not always objects of loathing and disgust. In former times people were more inclined to joke about them than to shudder at them, and some, it is said, even went so far as to be proud of their guests. In Hooke's "Micrographia," which, as we have already seen, was written some 230 years ago, there is a brief account of the head-louse, accompanied with an enormous figure representing a specimen magnified to the length of nearly two feet. Hooke introduces his description with the following highly suggestive passage:—"This is a creature so officious, that 'twill be known to every one at one time or other, so busie, and so impudent, that it will be intruding itself in everyones company, and so proud and aspiring withall that it fears not to trample on the best, and affects nothing so much as a Crown; feeds and lives very high, and that makes it so saucy, as to pull any one by the ears that comes in its way, and will never be quiet till it has drawn blood." Whatever we may think of the good taste of this passage, and the quaint conceit it contains, it is evident that personal cleanliness was not considered in the days of the Stuarts a matter of such vital importance as it has come to be regarded by respectable society in the Victorian era, and visions of the shady side of domestic life in the time of the "Merry Monarch" are called up, which it is as well to draw a veil over.

Man is not exceptional amongst mammals in harbouring these vermin, he is but in the same category with the rest; for it seems to be the rule, from elephant to mouse, largest to least, that some member of this group of parasites should be attached to each species, and even aquatic mammals, such as the seal and walrus, do not escape their attacks. But, just as the human flea is not

the same as those of other animals, so human lice are distinct from those which infest the lower mammalia, and indeed each species of mammal may be expected to have its own distinct parasite. Man, then, is not exceptional in *suffering* from these parasites, but rather in having to some extent, as has taken place amongst civilized nations, shaken himself free from them.

Of these disgusting insects three species are known to infest human beings, the head-louse (*Pediculus capitis*), the body-louse (*P. vestimenti*), and the crab-louse (*Phthirius inguinalis*). The first is the kind that occurs most commonly, and the last is the rarest. The two *Pediculi* are very much alike, the body-louse being best distinguished by the locality in which it is found, and by its larger size; the *Phthirius* is very different from both. Taking as our type the commonest species (Fig. 1), we may first note its structural peculiarities. It is a flattish, semi-transparent insect, of a pale ashy grey colour, with a comparatively small head and a very large body. The head, which is narrowed in front and behind, carries a pair of short five-jointed antennæ, a pair of simple, rounded, unfacetted eyes, and the mouth organs, of which more presently. Behind it merges into the thorax, which again is not definitely marked off from the abdomen, but the three pairs of legs show how far its three segments extend. The legs succeed one another without interval, and the first pair are placed immediately behind the head. No wings of any kind are ever developed, nor is any trace of such organs perceptible; hence some naturalists have questioned whether the lice should be included amongst insects at all. Not only is the thorax considerably broader than the head, but this increasing breadth is continued into the abdomen, so that the widest part of the insect is about half-way down the body. The margins of the abdomen show a scalloped edge, there being a series of indentations where the segments adjoin. On each of these rounded projections is placed a small circular spiracle, or breathing hole, the terminal orifice of a short tracheal branch. Six spiracles are thus arranged down each side of the body, and all the short branches from them join a great tracheal trunk which runs down each side parallel to the margin. The whole body is covered with minute scattered hairs, which are sharp-pointed and perfectly straight.

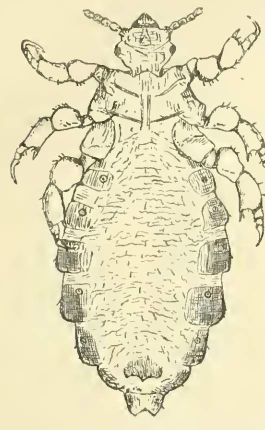


FIG. 1.—Head-Louse (*Pediculus capitis*). Female, viewed from beneath. Magnified 22 diameters.

The legs are composed of the usual parts, but all the joints are short and stout, giving an appearance of clumsiness, and the feet are extremely peculiar, their remarkable structure forming one of the distinctive characteristics of a louse. The tarsus, or foot proper, consists of two small joints, the division between which is not very easy to see, and these are succeeded by a terminal appendage in the form of a single, curved, movable claw of large size, which is usually carried bent more or less inwards, and is capable of being completely folded back upon the foot. At the end of the tibia, or shank, there is a movable pointed prominence, and by means of this, which acts as a sort of thumb, and the great claw, the insect is enabled to exercise that strong grasping and clinging power for which it is noted, and which is of great importance in its economy, facilitating its movements amongst the hairs in the midst of which its life is spent. In the figure one of the claws is shown bent back upon the "thumb," as in the act of grasping. The claws are very similar in shape to those of fleas, but differ in being single on each foot, instead of double.

In the structure of the mouth organs again, lice are exceptional. When the dead or inactive insect is examined, no mouth organs can be seen, for, when not in actual use, they are retracted within the head. The mouth is of the suctorial type, the insect feeding on the blood of its victims, to obtain which, an incision must of course be made through the skin. But, in consequence of its retractile character, there has been a great deal of difficulty in determining the real structure of the sucking apparatus, and it is necessary to carry out careful observations on the living or recently killed insect, before the details can be made out. The old Dutch naturalist Swammerdam took great pains in investigating the matter, and showed clearly that there was a suctorial proboscis, which could be thrust out from the head and entirely retracted again. But, as he himself says, "this proboscis is, on account of its diminutive size, not to be demonstrated except with great painstaking, and it is perhaps nothing but a piece of good luck if one succeeds in seeing it." This being the case, it is perhaps not surprising that since Swammerdam's time some authorities have denied the exclusively suctorial character of the apparatus, and have maintained that true biting organs are present, whence they attributed the irritation produced by the insects on their hosts to the effects of a real pinching bite. This, however, was a mistake arising from the fact that only dead specimens were examined, and those too under pressure, so that the apparatus could only be seen through the skin as it lay contracted inside the head, in consequence of which it was misinterpreted. About twenty-five years ago Professor Schiödte, a Danish naturalist, by careful observations on the living insect (in this case *P. vestimenti*), confirmed Swammerdam's statements, and determined with greater accuracy the true nature of the proboscis. He obtained an abundant supply of material from a workhouse (Danish), and having enclosed some specimens in a glass tube for two or three days without food, so that they might the more readily fall to when released from confinement, he transferred one of them to the back of his hand and prepared to watch its movements with a lens. He thus describes what followed:—"Scarcely does the abominable little monster feel the heat of the skin before it lays aside its former disheartened attitude, and begins to feel at ease, its antennæ oscillate for joy, and it stretches all six legs complacently out from the body. But though the pleasure and surprise at the sudden transportation into congenial surroundings for the first moment eclipse everything else, hunger soon asserts its claim, sharpened as it is by the long fast, which has rendered its stomach and intestines quite transparent. The animal raises itself on its legs, walks on a few steps, seeking and feeling its way with its antennæ, while we follow it with the magnifier. Presently it stops, draws in its legs a little, arches its back, bends the head down towards the skin at an oblique angle, while it pushes a small dark and narrow organ repeatedly forward, and

draws it back through the fore end of the head; at last it stands still, with the point of the head firmly abutted against the skin." While the animal was in this position he seized it gently with forceps, and endeavoured to detach it from the skin, hoping thus to see the extended proboscis. But in this he was disappointed, for though a slight resistance to his efforts was experienced, showing that the proboscis had really penetrated the skin, yet when the insect was detached, no trace of a proboscis, or anything of the sort, could be seen; it had instantly shot back into the head, and returned to the normal position of rest. This method therefore having proved ineffectual, the experimenter decided for a time to confine his observations to the upper surface of the insect during the progress of its meal, so as to watch, through the transparent skin, the gradual drinking in of the blood. Allowing it therefore to attach itself once more, he sees "at the top of the head, under the transparent skin, between and a little in advance of the eyes, a triangular blood-red point appear, which is in continual movement, expansion and contraction alternating with increased rapidity. Soon this pulsation becomes so rapid that several contractions may be counted in a second." Swammerdam also had noticed this, and likened the rapid movements of this little pumping machine to the quick oscillation of the balance-wheel of a watch. Schiödte continues, "the whole digestive tube is now in the most lively peristaltic movement, filling itself rapidly with blood, as is easily observed: the long œsophagus is particularly agitating, throwing itself from one side to another inside the neck, bending itself so violently as to remind one of the coiling of a rope when being shipped on deck."

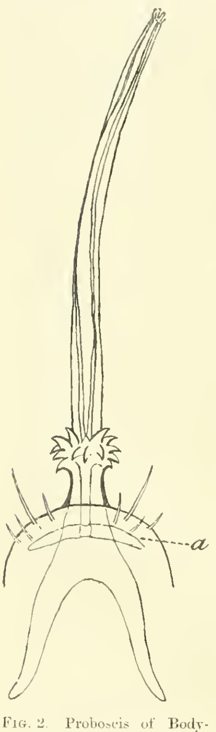


Fig. 2. Proboscis of Body-Louse. (After Schiödte.)

The insect was now thoroughly hard at work, and this was therefore the opportunity for the next stage in the proceedings. In order to prevent the retraction of the proboscis which would have followed the withdrawal of the insect, the experimenter determined to decapitate it suddenly, hoping that thereby the proboscis might remain extruded. The fore part of the insect was therefore rapidly severed with a pair of fine scissors without previously disturbing it in its feast. The decapitated head, having been left as it was for a short time, was then gently raised with forceps, and the proboscis gradually withdrawn; the whole was then transferred to a slip of glass and placed under the microscope without pressure. The appearance presented was such as is shown in the accompanying diagram (Fig. 2). A long fleshy tube was depending from the mouth, at its base was a stouter part furnished at its apex with a number of hooks, but the rest of the tube was thin, flexible and transparent. Within the latter could be traced four thin chitinous bands, the representatives of the two pairs of jaws, the mandibles and maxillæ of the ordinary insect's mouth. Thus we have an arrangement resembling in some degree that of the mouth of the bed-bug and other Hemiptera, a tubular labium containing four setæ, the mandibles and maxillæ. During the process of the extrusion of this apparatus the first part to appear is the strong base of the tubular labium, but the hooks are at first inside the tube. They can, however, be everted, and by a continuance of the same process the membranous lining of the tube is brought out and forms the long delicate sucker which constitutes the greater part of the proboscis. The labium having been inserted into the skin, say through a sweat pore, the hooks become everted and hold the proboscis steady by clinging to the tissues around. The piercing mandibles are then thrust out; towards their tip they are united into a tube from within which the second pair of setæ is protruded, similarly united, and terminating in four small lobes, which seem to act as feelers. All this mechanism can be thrust out to varying distances, and hence the length of the exserted proboscis can be accommodated to the thickness of the skin of the victim in the particular place in which the animal is feeding; by this means the capillaries of the host are at length reached, when blood will at once ascend the proboscis, the flow being accelerated and continued by the vigorous action of the pump-like cavity in the digestive tube already mentioned.

But to return to our decapitated head. The observer, wishing to examine the structure of the proboscis under a higher power of the microscope, put it under pressure for that purpose, when instantly the whole apparatus shot back into the head, and no further observations could be conducted; in this position the two sides of a chitinous band marked *a* in the diagram look something like biting jaws, and had been mistaken for such by those who had not seen the protruded instrument. These appear as a dark band across the under surface of the head in Fig. 1, which was drawn from a specimen prepared for the microscope, and therefore more transparent than usual, and beneath them the outlines of the retracted proboscis can be traced. Schiödte had to carry out many other observations on specimens prepared in a variety of ways before the whole of the details enumerated above could be determined, and whoever wishes to verify these results must be prepared to exercise great patience in the investigation. Leeuwenhoek was so much struck with the beauty and delicacy of this feeding apparatus, even so far as it was known in his time, that he appeals to its complex character as evidence that a creature which possesses so elaborate a sucking pump could not have been, as was formerly believed to be the case, spontaneously generated from "dirt, sweat, or excrements," but must have an origin similar to that of more highly organized animals.

(To be continued.)

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

To the Editor of Knowledge.

Dear Sir,—I beg to enclose for insertion in your paper what I claim to be a fresh discovery in figures, should you think it worthy of your notice. How to tell by inspection whether a number is or is not a perfect square or a perfect

cube is made much easier by knowing the following rule :—"If the sum of the digits in its simplest form equals any of the following numbers it cannot be a perfect square, *i.e.*, 2, 3, 5, 6 and 8; and the number can only be a perfect cube when the sum of its digits, reduced to its simplest form, equals one of the numbers 1, 8 or 9." It is also an interesting fact that the sum of the digits of the squares of consecutive numbers recur in the following order—1 4 9 7 7 9 4 1 9, and similarly the sum of the digits of perfect cubes recur in the order 1—8—9.

Explanatory Table.

Number.	Cube.	Sum of digits.	Number.	Cube.	Sum of digits.
1^3	1	1	7^3	343	10=1
2^3	8	8	8^3	512	8
3^3	27	9	9^3	729	18=9
4^3	64	10=1	10^3	1000	1
5^3	125	8	11^3	1331	8
6^3	216	9	12^3	1728	18=9

And so on *ad infinitum*.

Number.	Square.	Sum of digits.	Number.	Square.	Sum of digits.
1^2	1	1	10^2	100	1
2^2	4	4	11^2	121	4
3^2	9	9	12^2	144	9
4^2	16	7	13^2	169	16=7
5^2	25	7	14^2	196	16=7
6^2	36	9	15^2	225	9
7^2	49	13=4	16^2	256	13=4
8^2	64	10=1	17^2	289	19=10=1
9^2	81	9	18^2	324	9

And so on *ad infinitum*.

Yours faithfully,

London, 3rd November, 1891. A. W. Gordon.

[Mr. Gordon's note may interest some of our readers. His test for cube numbers is so obvious from theory that he is probably mistaken in regarding it as a fresh discovery. The test is useful, as it enables the cube hunter to discard two-thirds of the numbers which may come before him, and Mr. Gordon's test for square numbers enables him to discard five-ninths of the numbers he may have to deal with, but it is not as easy to remember as the well-known test already referred to in Knowledge by Mr. Christie and Mr. Barrett, viz., that numbers which are perfect squares cannot end with the digits 2, 3, 7 or 8, but both of the tests for square numbers may be applied successively.

Mr. Gordon's test for cube numbers follows from the fact that all perfect cubes are either multiples of 9, or when divided by 9 a remainder which is either 1 or 8 is left. When the number is divisible by 9 the sum of its digits is equal to 9, and when the remainders 1 or 8 are left the sum of its digits must be either 1 or 8. The rule with regard to the division of cube numbers by 9 follows directly from the fact that a number which is divisible by 3 must when cubed be divisible by 9, while a number which is divisible by 3, leaving a remainder 1, must when cubed and divided by 9 leave a remainder 1, for

$$(3n+1)^3 = 3^3 n^3 + 3 . 3^2 . n^2 + 3 . 3 . n + 1$$

which must be a multiple of 9 plus 1, and a number which is divisible by 3, leaving a remainder 2, must when cubed and divided by 9 leave a remainder 8, for

$$(3n+2)^3 = 3^3 n^3 + 3 . 2 . 3^2 n^2 + 3 . 2^2 . 3 . n + 2^3$$

which is a multiple of 9 plus 8.

Mr. Gordon's test for square numbers follows from the fact that to pass from the square of any number n to the square of the number immediately above it we must add $2n+1$, or what amounts to the same thing, the square of any number n may be found by adding together the first n terms of the series $1+3+5+7+9+11+$ &c. The sums of the digits of consecutive numbers recur in the order 1, 2, 3, 4, 5, 6, 7, 8, 9; therefore, if we pass along this recurring series with steps of increasing length, beginning at 1 and stepping 3 intervals at the first step, 5 at the second, and so on, we shall step from the sum of the digits of one square to the sum of the digits of the next, and shall always avoid the numbers 2, 3, 5, 6 and 8, for they are avoided in the first eight steps, and afterwards the same numbers are avoided because the subsequent steps are similar to the first eight steps, except that they are each eighteen intervals longer, and eighteen intervals corresponds to two complete circuits of the recurring series. Thus the sums of the digits of the squares of successive numbers are marked with a point above them :—

$$\dot{1}23\dot{4}5678\dot{9}123456\dot{7}89123456\dot{7}891234567 8\dot{9}1234$$

$$56789123\dot{4}56789123\,156789\dot{1}23456789\,12345678\dot{9}123$$

A. C. Ranyard.]

SNAKE POISON.

To the Editor of Knowledge.

Sir,—Two years and a half ago you were good enough to open your paper to a discussion between Mr. Field and myself on the subject of experimenting on animals with snake poison. Mr. Field, who had performed in France some mild experiments on mice in this line of research, took occasion in writing for you on the "Common Adder," to make the following remarks :—

"When we think of the thousands of our fellow men who die annually by reason of our want of knowledge with respect to snake poisons, the importance of experimenting on living animals (*for by these means alone can an antidote be found*) in this case cannot be over-estimated. . . . We may truly say then, that he who hinders the progress of such investigations commits a sin against mankind." Knowledge, February, 1889.

Naturally I protested against this view, and asserted that "he who, for the sake of remote and doubtful physical benefits to our race, encourages a practice which unquestionably must stifle the impulses of compassion in the human soul, is the real sinner against mankind." I also quoted the *Encyclopædia Britannica*, vol. xxii., p. 191, to contradict Mr. Field's statement, "an antidote has been discovered," the *Encyclopædia* elaborately explaining that "*no* antidote is known capable of counteracting or neutralizing the action of snake poison."

After two years my contention has been so remarkably confirmed that I must ask your permission to refer your readers, who may take interest in the controversy, to no less an authority than the columns of the *Lancet* (October 24th, p. 960), for the fullest satisfaction on the subject. They will there learn that "a country practitioner at the Antipodes discovered the antidote and for years practised it with unfailing success, when Feoktistow, *misled by his experiments*, rejected it." Mueller's theory, derived from careful observation with *no* vivisections experiments, has proved a true and vast benefit to humanity, while those experiments on animals which Mr. Field asserted were the "*only* means" of discovering an antidote, not only failed to result in such a discovery, but actually put the investigator on a wrong scent, and *prevented* him from finding what was before his eyes!

I am, Sir, truly yours,

Frances Power Cobbe.

[I do not agree with Miss Cobbe's interpretation of the paragraph in the *Lancet*, but I will ask Mr. Field to allow the lady to have the last word, as the controversy is not suitable for the pages of Knowledge, and must now come to an end.—A.C.R.]

To the Editor of Knowledge.

Sir,—At page 192 of the October issue you say: "Everyone is familiar with the earth-smell of the air after a shower of rain, when the lowered pressure of the barometer allows the air which has been forced into the soil to rush back to the surface." Being a very early riser, and fond of working in the garden, one of my daily pleasures at this time of the year—often before daylight—is watering the flowers. The "earth-smell" you speak of is very familiar to me, and all through our hot summer weather (practically *rainless*) its pleasant, refreshing odour is one of the satisfactions of my morning work. Let me ask if it is not likely that some chemical process may be the cause of the grateful aroma, for how, in the instance I speak of, could lowered barometric pressure find place as a cause? If I water in the evening, and the ground is damp when I renew work in the morning, no earth-odour is perceptible. Yours obediently,

Charles F. Hart.

The Oaks, Claremont, California,
October 16th, 1891.

[I do not remember to have noticed the earthy smell except after a shower of rain. No doubt it is due to some chemical change which takes place on the contact of air with freshly wetted earth.—A.C.R.]

THE UPPER ATMOSPHERE.

To the Editor of Knowledge.

Sir,—Your article in Knowledge under this title makes me wish to ask if it is not possible that the earth in times long past gradually robbed the moon of her atmosphere?

You state that a velocity of 7 miles per second would carry gaseous molecules right away from the earth's upper atmosphere into space.

What speed would carry such molecules *from the moon to the earth?* and is such speed possible or probable?

A note in Knowledge on this question would I think be of general interest. Yours respectfully,

W. M.

P.S.—If the moon used to be much nearer the earth, as Prof. Ball has supposed, and if her recession was slow, what effect would that have on the supposed gaseous-robbing powers of the earth?

[A velocity of a little more than $2\frac{1}{4}$ miles per second would be necessary to carry a projectile shot vertically upwards from the moon's surface out of the region of the moon's attraction. This is so much greater than the mean velocity of the molecules of our atmosphere at temperatures such as probably exist on the moon, that it seems improbable that the most swiftly moving gaseous molecules could escape from the region of the moon's attraction. If in the earlier stages of the moon's history the moon and earth ever had a common atmosphere it seems more probable that the moon would have robbed the earth of its atmosphere rather than that the earth should have robbed the moon. For the moon, by reason of its greater surface compared with its mass, must from a very early stage have cooled faster than the earth, and the cooler body would, under such circumstances, tend to rob the hotter, as the gases would condense upon it while they still formed a lofty atmosphere about the hotter body. Whatever was the initial condition, there must have been a great evolution of gases during the formation of the lunar volcanoes. Our own geologic history shows that there has been a continual evolution and absorption of gases by terrestrial rocks, and probably similar changes have taken place upon the moon.—A. C. Ranyard.]

DARK STRUCTURES IN THE MILKY WAY.

By A. C. Ranyard.

The first plate which illustrates this paper has been made from a photograph taken by Dr. Max Wolf, of Heidelberg, with an exposure of eleven hours seven minutes made on three different nights, viz., the 11th, 12th, and 13th September, 1891.

It represents a region of the Milky Way in the constellation Cygnus on the following, or eastern side of the region represented in the large plate published in the October number of Knowledge. The nebulous star α Cygni, which was near to the centre of the plate in the October number, is here seen near to the edge of the plate on the right hand or "preceding" side. Vertically above α Cygni the dark branching structure, an outline of which is given in Fig. 1, will easily be recognized. The reader may assure himself that this tree-like structure is not due to a photographic defect by comparing the plate in the October number with this plate, as well as with the right-hand picture on our second plate, which is a photograph on a much smaller scale of the same region, but includes a greater area of the heavens. This latter photograph was taken by Dr. Max Wolf in a small camera fixed upon the top of the large camera, and driven by the same clock motion. The two cameras were rigidly attached to a telescope, which enabled the driving of the clock to be controlled and the cameras to be accurately directed to the same region of the heavens from night to night. The accuracy with which this has been done is attested by the photographs obtained; even the smallest stars shown are represented by minute white patches, which appear approximately circular, though our plates are enlarged more than two diameters from the original negatives.

Fig. 1.—Diagram showing small dark tree-like structure to the north of α Cygni.

Our first plate, representing the region about ξ Cygni, was taken with the $5\frac{1}{4}$ inch Kranz aplanatic camera, described in the October number, and the right-hand picture on our second plate was taken with a smaller camera fitted with a portrait lens of only 55 millimetres (about $2\frac{1}{5}$ inches) aperture and 195 millimetres (about 7·8 inches) focal length. The photograph taken with this small camera will bear examination with a lens, and a comparison of it with our first plate and the plate published in the October number is most instructive. The tree-like structure represented in Fig. 1 will be distinctly recognized in all three photographs as darker than the surrounding area. It evidently corresponds to a branching stream of matter which cuts out the light of a nebulous background on which it is seen projected, and it is evidently intimately associated with the lines of stars which border the stream and its branches on either side. In addition to the large stars which lie along the edge of the dark area, lines of very minute stars may be traced within the dark structure—they seem to fall into lines conformable to the main stream and branches. A somewhat similar dark branching stream may also be traced on the photograph of the ε Cygni region in the October number. One of its branches runs close to ε Cygni, and passing northward again branches. The structure represented in Fig. 1 seems to be connected at its base

photograph of the Sagittarius region. The picture of the Sagittarius region on our second plate does not show Mr. Barnard's dark arch as well as the pictures published with the August number of Knowledge, 1890, or the denser pictures published in the "Old and New Astronomy," plate xxviii, but there is no doubt about its existence, or the existence of the prominence-like structures which spring from its eastern or convex side. As remarked by Mr. Barnard in the paper accompanying his photographs (published in the *Monthly Notices*, vol. L., p. 314), this dark lane or arch amongst the stars seems to be intermediate in distance between the different bright structures shown upon the plate. It evidently lies in front of the bright structures shown on the lower and upper parts of the plate, and seems to be crossed or broken in upon by one of the bright structures at A′.

Fig. 5 is an index map which indicates the position of

Fig. 5. Diagram indicating the position of dark tree-like structures traceable on Mr. Barnard's photograph of the Sagittarius region.

two dark tree-like structures, C and B, which both seem to spring from the dark region D at the bottom of the Sagittarius plate. From this same region also springs the bright tree-like structure indicated in outline in Fig. 6. The dark structure C seems to lie in front of the bright tree-like form shown in outline in Fig. 6. This bright tree-like form, as well as the dark structures B and C, all seem to have had their origin in the dark region D, and to indicate the existence of colossal outrushes of matter into a resisting medium.

Fig. 6. Diagram showing outline of bright tree-like structure, visible on photograph of the Sagittarius region.

Like the comparatively small dark structure indicated in Fig. 1, these larger dark structures seem to be associated with bright stars which lie along their borders, though the stars are not arranged in such definite lines or streams along the edges of these large dark regions as they are along the borders of the narrow dark channels, and smaller tree-like structures such as that shown in Fig. 1 and at the summit of C, Fig. 5. It will be noticed also that the dark region at the bottom of the plate is bordered by two conspicuous star clusters. The dark regions in the trifid nebula are also bordered by lines of stars, and the dark patches or holes in the Milky Way, referred to in the October number (a striking example of which is shown in Mr. Barnard's photograph), are surrounded by circles of stars. It is evident that there must be some intimate connection between the dark regions, or the absorbing matter they contain, and the stars surrounding them. In the case of the solar prominences we know that the tree-like forms are due to masses of glowing gas shot upward into a resisting medium; and it seems very probable that the tree-like structures of the Orion nebula also consist of gaseous matter, for they are the brightest parts of the nebula, and the spectroscope shows that the chief part of the light of this nebula is emitted by incandescent gas. Have we, in the Milky Way, gaseous phenomena on a still more colossal scale?

Notices of Books.

Primitive Folk. By Elie Reclus (Walter Scott).—In this volume of the "Contemporary Science Series" we have an intensely interesting description of the manners and customs of some very little known nationalities, the Inoits or Esquimaux, the Apache Indians, and some of the hill tribes of India. Starting with the motto that "to travel over space is to travel over time," the author goes to the remote regions inhabited by these tribes in order to see man as one might expect him to have been in the youngest days of his history. Just as the embryologist reads something of the past history of a species by an examination of the phenomena the organism now presents in its earliest stages, so the ethnologist tries to recover something of the history of the progress of the human species by observations on those examples of it which are now in the most elementary condition. The idea is a fascinating one; indeed, as the author says, "certain customs, the meaning of which has never been suspected even by those who practise them, are in their own way as interesting as it would be to an archæologist to unearth a lacustrine city, or to a zoologist to discover a pterodactyl dabbling in an Australian marsh"; and its interest is still further enhanced by the keenness of perception which the author

The Region of the Milky Way about ξ Cygni.

Enlarged from a photograph taken by Dr. Max Wolf, of Heidelberg, with a portrait lens and thirteen hours' exposure, on the 9th and 10th September, 1891.

Region of the Milky Way in Sagittarius.

From a photograph taken by Mr. C. E. Barnard. Centre of picture, R.A. 17h. 56m., South Dec. 28°. Scale 1 in. = nearly 2°.

frequently displays in detecting fundamental similarities in widely different customs. He deals chiefly with the subjects of marriage, government and religious rites, but the pictures he draws do not represent things as they now are, but rather as they were half a century ago, before civilization had tampered much with the tribes in question; for, as the author states, "scarcely any primitive folk are now in existence; soon there will be none." The pictures of savage life are often horrible and disgusting enough, completely refuting the pleasing theory of the "noble savage." But even in the most disgusting practices and the most degraded rites, M. Reclus again and again finds ideas similar to those that lie at the root of many of the most respectable institutions of the civilized world. However, as degeneration and decline are admittedly factors in human history as well as progress and growth, it does not always seem clear whether, in the strange customs of these so-called primitive races, we may not be dealing with deteriorated remnants of something that was once nobler and better, rather than with the initial stages of that which in other nations, and under a more favourable environment, has developed into modern civilization; whether we have not debased relics instead of undeveloped germs; whether in fact, the name *primitive* folk, if taken in its literal sense, may not possibly involve a begging of the question. But however this may be, there is no question that in the book before us we have a valuable and interesting contribution to the literature of ethnology, as well as a series of essays which will stimulate thought and encourage enquiry.

British Ferns. By E. J. Lowe, F.R.S. (Swan Sonnenschein and Co.)—This is the fern-book of the "Young Collector Series," and as a record of the distribution and variation of our British ferns it is a marvellous shilling's-worth, and represents an enormous amount of careful work. The author has aimed high, so high indeed that we are inclined to wonder where the "young collectors" are to be found whose wants will be exactly met by this little book. One of his chief aims appears to have been to illustrate the extreme flexibility of type which ferns exhibit, and in this he has certainly succeeded admirably. A very large proportion of the book is taken up with the enumeration and brief characterization of varieties of the different British species, amongst which the common hart's tongue attains the maximum of variation; to this species alone 28 pages are allotted for the description of upwards of 400 varieties. So much space is occupied with this exhaustive treatment of varieties that no room is left for such matters as the generalities of fern structure and development, the distinctions between ferns and other plants, &c., some of which one might fairly expect to find explained in a beginner's text-book, written on scientific lines. The fern collector who wishes to make use of this book must lay his foundations elsewhere, and when he has acquired a good general knowledge of his subject, he can use Mr. Lowe's help in the study of varieties to his heart's content. Some useful hints are added as to fern growing and collecting, and some remarkable varieties are nicely figured.

On Surrey Hills. By "A Son of the Marshes" (Blackwood and Sons).—No more delightful book has come from the pen of the Kentish naturalist who, under the above *nom de plume*, has so often charmed the readers of "Blackwood," than this collection of essays on Nature as she is to be seen in the wilds of Surrey. It seems strange to talk of wilds in connection with a county into which suburban life is so rapidly pushing its way; and yet, as none know better than those who have been there, within little more than an hour from the roar and din of the Metropolis there are to be found on the Surrey hills places as lovely and silent as though they were in the remote Highlands of Scotland, where some of the fast-diminishing wild fauna of our islands still flourish comparatively unmolested. These little visited, but lovely and picturesque, spots were for many years the arena of our naturalist's observations, and in this book, with the assistance of the editorial pen of Mrs. J. A. Owen, he has recorded his impressions in simple but vivid pictures which cannot fail to interest and delight the reader. The accuracy of his notes proves him a keen and patient observer, in ardent sympathy with Nature. He is never better pleased than when watching the wild creatures of hill and dale, roadside and stream. Bird, beast, fish, or insect, it is all one to him: he loves Nature for her own sake, and wherever life of any sort disports itself there is he to be found, early and late, playing the spy upon it, and enjoying to the full the novelties of the scene. There is an air of freshness and freedom about these realistic sketches that is quite exhilarating, while the genial spirit which pervades them, the strong human interest exhibited, and the frequent touches of humour, combine to make "A Son of the Marshes" a capital companion.

An Account of British Flies (Diptera). Part I. By the Hon. M. Cordelia E. Leigh and F. V. Theobald, B.A. (Elliot Stock). At last we are to have a popular book on British Flies. The authors aim at catering for the wants of the young student of Dipterology, and they hope to be able also to entice to their ranks some stray collectors from amongst the devotees of the more popular orders of Butterflies and Beetles. With a courage which deserves success, they have undertaken the herculean task of describing the enormous host of British Diptera, large enough in Walker's time, but greatly augmented since the publication of "Insecta Britannica," forty years ago. Six parts are to be issued annually; the first, which has just appeared, contains a concise sketch of fossil Diptera, an account of various classifications of flies, and descriptions of some species of fleas. Life-histories, especially of agricultural pests, are to be fully dealt with, and occasional illustrations are to be added; those in the present number are scarcely up to the mark, the figure of the human flea especially being decidedly unsatisfactory. The classification followed will be that adopted by Mr. Verrall in his recently published list.

EXPLOSIONS ON PETROLEUM VESSELS.

By Richard Beynon, F.R.G.S.

THERE is probably no department of British industry that has developed with such phenomenal rapidity as the Petroleum trade, and so far as present appearances are concerned there is every prospect of it undergoing much further expansion. The earlier shipments to this country were conveyed in barrels, but the evolution of the tank steamer has completely revolutionized the economics of the Petroleum trade. It is proposed in the present paper to discuss the adaptability of existent methods of transit to the requirements rendered necessary by the over-sea conveyance of crude Petroleum with its accompanying inflammable vapours.

Crude Petroleum or Naphtha may be described as an inflammable liquid hydrocarbon, or rather as a compound of several hydrocarbons. According to some authorities these are three in number: $C_{14}H_{13}$, $C_{16}H_{16}$, and $C_{24}H_{22}$. Each of these compounds has a different boiling point, that of the last named being the highest. The ordinary Petroleum of commerce boils at the low temperature of 120° Fahrenheit, and is exceedingly volatile. Of the native

occurrence of this oil there is no need to speak, the names Petroleum, *rock oil*, and Naphtha (Persian *nafata—to exude*), being sufficiently indicative of its origin. There is probably no country in the world that does not possess Petroleum-bearing strata, but the comparative small expense with which the American and Russian springs can be worked keeps out from the market oils which cost more to obtain. The Russian oil trade is conducted on the simplest lines possible. Pipe lines are laid down to conduct the oil from the wells to the refineries. Thus between Balakhani and Baku there are some seven lines of cast-iron pipes of six inches diameter, and through these pipes there flows in a day 2,000,000 gallons of Petroleum. The process of purifying is a simple one, and merely involves the employment of a series of stills, each one of a higher temperature than the preceding one. In one of these stills the Petroleum loses a portion of its constituents, in one the more volatile oils, in another the paraffin; further on, the heavy lubricating oils, and last of all there is the "residuum," as it is styled in America, or "astatki" by the Russian distillers. The commercial value of this residue it is at present difficult to assess, but many engineering experts are of opinion that it is far superior to coal as a steam raiser.

The type of vessel which the conditions of the Petroleum trade has called into existence is that aptly described as the tank steamer, which is simply a vessel divided by transverse bulkheads into watertight compartments or tanks, in which the oil is carried in bulk. The tanks may be divided by a longitudinal bulkhead, which reduces their size to one half. Expansion tanks are provided, and man-holes give the men free access to the tanks. In tank steamers the propelling engines are aft, and two bulkheads, with a space between them, are interposed between the aftermost tank. The object of this is to supply a chamber into which the leakage from the tanks may collect, as well as oppose a barrier between the engine space and the oil tanks. Cases are on record where the leaked oil has found its way into the bunkers, with the result that the coals were saturated with oil, and great risk of explosion incurred. Where this intervening space is stored with water the oil accruing from leakage can be easily removed, as by reason of its lesser specific gravity it finds its way to the surface and can be skimmed off, and thus the generation of the dangerous Petroleum vapour is obviated. Tank steamers are fitted with electric light, and the double wire system is being extensively adopted in preference to the more questionable method of employing the single wire with the iron hull of the vessel as the return. The danger of the latter system of installation often militates seriously against successful navigation; as, apart from other risks, the single wire system has been known to produce an error in the ship's compass of from 3° to 7°. Where portable lights are required on a Petroleum ship, wires are switched on to the main cable, and the lamp is usually protected by a strong glass container and a stout wire protector. Such are briefly the outlines of the existent machinery for the over-sea transit of Petroleum in bulk.

It is somewhat remarkable that the destruction of Petroleum vessels by explosion and fire does not seem to be brought about directly by the cargo itself, but rather by the residual vapour which remains in the hold spaces when the oil is partially or wholly discharged.

The dangerous character of this vapour is well known, and its accumulation in a space employed to carry quantities of crude oil not yet deprived of its most volatile constituents must be regarded as an inevitable adjunct to the risks of Petroleum carriage. The maximum danger in the case of tank steamers is reached after the discharge of the oil has taken place, for the oleaginous properties will ensure its adhering to the sides of the tanks when the pumps have removed all they can. One volume of this crude oil is sufficient to render feebly inflammable 2400 volumes of air, and the exposure of such a great evaporating surface supplies the most favourable conditions for the generation of Petroleum vapours. In the bottoms of the tanks there is usually some inches of oil which remains even after the tanks have been filled with sea water and pumped out again. Evaporation must of necessity go on rapidly from such a shallow surface, and the result is that the tank becomes, unless *adequate* means are employed to cleanse and ventilate, a danger space of the most pronounced type.

A brief sketch of three typical disasters occurring on Petroleum vessels will show the glaring deficiencies of the precautionary measures at present adopted in the Petroleum carrying trade. On the 19th December, 1889, the steamship *Fergusons* was discharging at Rouen a cargo of crude oil, shipped at Philadelphia, when a fearful explosion took place, blowing out the mainmast and completely wrecking the after-part of the vessel. In spite of all efforts to extinguish the flames the fire raged until the next day, when the vessel foundered. No trace could be discovered of one of the tank men who was below at the time of the disaster. Her Majesty's Consul at Rouen forwarded to the Home Office a sample of the crude oil carried by the *Fergusons*, and this, on examination by Dr. Dupré, chemical adviser to the Explosives Department of the Home Office, was found to have at the normal temperature a specific gravity of ·7925. This crude oil contains all the most volatile constituents of Petroleum, and this particular sample was capable of rendering inflammable 2400 times its own volume of air. Thus, a gallon would suffice to render inflammable 400 cubic feet of air, and its volatility may be judged of by the fact that the exposure of one foot of oil surface for twenty minutes will make thirteen cubic feet of air explosive. Now, although the employment of electric lighting on oil ships tends in the main to minimize risk, yet imperfect installation supplies a ready method of igniting this Petroleum vapour. At the time of the disaster the dynamo was running, and there is little doubt that the emission of a spark consequent upon the faulty contact of the portable cable and lamp led to the disaster.

Some little while after this the nautical world was startled by the news of a disaster almost without a parallel in the annals of our mercantile marine. A tank steamer, the *Wildflower*, constructed in 1889 for the Petroleum trade and fitted with six cargo tanks, each holding 500 tons weight of oil, was engaged to convey a cargo of crude Petroleum from Philadelphia to Rouen. The voyage was accomplished in safety, and the discharge of the oil was effected satisfactorily until the pumps sucked, leaving in the tanks a depth of oil varying from two to six inches, while in one tank there was some fifteen inches of the crude oil left. Two of the tanks were pumped full of water. The vessel then left Rouen, and on January 8th, 1890, she arrived in the Wear, where she was moored. The tanks were then pumped out, and it was noticed that an oily film spread over the surface of the Wear and was carried seawards by the ebbing tide. Hardly were the pumping operations concluded when an alarm of fire was raised, and the surface of the water in the vicinity of the vessel was covered with smoke and flame. The adjacent shipping was much damaged, the surging flames enveloping them and extending seventy feet into the air, burning the rigging and buckling the stout iron plates with most disastrous effects. One life was lost. Most probably the firing of the oleaginous

film was effected by a red-hot rivet or a piece of burning waste thrown overboard from some ship contiguous to the *Wildflower*. Experiments made with some oil taken from the tanks showed a specific gravity of ·7185, and a power per gallon of rendering inflammable 133 cubic feet of air. When the oil was poured upon water the resulting film was easily ignited by a flame or any brightly red-hot solid. The evaporation of its volatile properties was so rapid that in ten minutes a lighted match failed to ignite the oil, while with twenty minutes' exposure it was necessary to blow a flame upon it to set it on fire, and after half-an-hour it was very difficult to light the oil by any means whatever. The teaching of the *Wildflower* disaster is too important to be ignored. It is dreadful to contemplate what accidents may occur through the presence of Petroleum upon the surface of the waters of crowded harbours. At Batoum the water is usually covered with oil to the distance of three-quarters of a mile from the shore, while practically the same condition of things obtains at Philadelphia.

The teachings of Petroleum disasters are, however, by no means limited to the above two cases. The latest horror occurred on board the steamer *Tancarville*, when in the dry dock at Newport, on the 11th May last. Like the *Wildflower*, the *Tancarville* was built in 1889, and specially constructed for the carriage of Petroleum in bulk. The oil tanks were six compartments, extending from the skin of the ship up to the lower deck, and were sub-divided again by a longitudinal bulkhead. Each tank was fitted with an expansion space, and these again were provided with man-holes. The vessel was equipped with the electric light on the double wire system. The cables were enclosed in a wooden frame and thoroughly insulated from each other. Switches were provided for the purpose of effecting communication between the main and portable cables. The connection was made by a ball and socket lever and covered with a brass cap. There were six portable cables, and the portable lamps were protected by clear glass globes of considerable thickness over the incandescent globes, the glass globes again being protected by four brass bars. The vessel was employed in carrying crude Petroleum from Philadelphia to Havre. She discharged her last cargo there and sailed for Newport on April 18th, which port she reached two days later, and was placed in dry dock on the same date. She went into dock a "dirty ship," *i.e.*, one which was not properly cleansed. A considerable quantity of oil was known to be in the ballast tank, which was a space of about 6000 cubic feet. Some of the oil remaining in the vessel was discharged into the dock and a red-hot rivet falling upon it set it on fire, doing considerable damage to the vessel. This was on the 23rd April. The vessel remained under repairs until May 11th, when an explosion occurred which wrecked the vessel and resulted in the loss of six lives. Several portable forges were being used on board the vessel, as much rivetting of her tanks was necessary. The residual oil in the ballast tank was removed so far as possible by drilling a hole in the bottom of the vessel and allowing the oil to run through into the dock. It was in this ballast tank that the explosion occurred with the violence stated above. The immediate cause of the disaster it is impossible to ascertain, but where portable forges and rivetting are carried on in spaces adjacent to those in which Petroleum vapour must have accumulated, a catastrophe is simply invited. The flames, according to some witnesses, reached as high as the top of the fore-mast, and the wrecking of the vessel is proof of the powerfully explosive character of Petroleum vapour. Assuming that one gallon of the oil would render 200 cubic feet of air feebly, and sixty cubic feet of air strongly, explosive, it will be seen that the presence of very little oil would suffice to fill the empty space of the ballast tank with a highly explosive compound.

What alterations in the pumping and ventilating appliances these disasters will lead to will be watched with the greatest interest. The better cleansing of oil steamers should be insisted upon. Spaces into which oil may leak are perhaps greater sources of danger than the tanks themselves, and adequate provision should be made for their effective cleansing in a thoroughly scientific manner. But the machinery of Petroleum conveyance needs revising and bringing up to date. The powers of harbour authorities are very limited, and they could not make bye-laws that would much diminish the risk unless the owners, and those who have to see to the details of the traffic, become alive to the dangers. They, by the loss of their lives and property, have already the highest incentive to adopt precautions. Refined Petroleum that has a higher flashing point than 73 Fahr. (Abel test), *i.e.*, "mineral oil," as distinguished from "mineral spirit," is outside the pale of the law. The dangers from oils whose vapours ignite at low temperatures are obvious. An eminent firm of oil manufacturers say that they have found some oils *offered for lubricating purposes* which gave off *dangerous* gases at a temperature of between 70 and 80° Fahr.

The Petroleum trade has developed enormously, and is still doing so. It can hardly be said, however, that the conduct of the trade is prosecuted according to the present teachings of science. The development of the trade has been attended with a much greater amount of disaster than even the dangerous nature of Petroleum warrants, and it is to be hoped the object-lessons of the accidents discussed will appeal to all those responsible for a diminution of them. One feature of the trade cannot be too strongly deprecated. The carriage of Petroleum in bulk requires vessels of a vastly different type to the average merchant vessel. Yet the British shipmaster, if he possesses the regulation Board of Trade master's certificate, is considered competent to command a tank steamer, with all its special mechanical apparatus for tank discharge, &c., and electrical equipment. Special conditions require special training, and, at the very least, there should be on every oil steamer a skilled electrician competent to effect repairs and to see that the electrical lighting is carried out on scientific lines.

SEA-URCHINS.

By R. Lydekker, B.A.Cantab.

PROBABLY most visitors to the seaside are more or less familiar with the shells of those marine creatures commonly known as Sea-Urchins, or Sea-Eggs, this acquaintance being usually due either to finding them cast up on sandy beaches, or to seeing them offered for sale by the vendors of curiosities and natural history objects. In many instances it is probable that the acquaintance ends here, although in others these objects may have been submitted to a fuller examination; but, in any case, we venture to say it is comparatively few who have studied them with the care and attention that their beauty of form and peculiar structure demands, and still fewer who know anything about their history in past times. Those, however, who care to take up the subject will find it one of more than usual interest, and we accordingly propose in this article to place before the reader some of the leading features and

peculiarities of these creatures, which will form stepping-stones for those inclined to proceed further with their study.

To begin with, Sea-Urchins take their name from the array of movable spines with which the shell is covered during life, and which thus suggest comparison with those of the true Urchin, or Hedgehog. The shell, as it is commonly called, will, indeed, be the portion of the animal to which alone our attention will be directed, since it is only this part that is capable of preservation in a fossil state. We must, however, state at the outset that, as this so-called shell does not by any means correspond in structure with the shell of a mollusc, it is found more convenient to give it a different name, and the term *test* has accordingly been selected. Moreover, since the name Sea-Urchin is a somewhat long one, we may conveniently abbreviate it to Urchin, unless we prefer to use the more technical term Echinoid.

There is great variety in the form of the hard calcareous test of the Urchins, which varies from a shape somewhat resembling a flattened orange to a heart-shape, or even to a thin disc-like plate. The ordinary Urchins shaped somewhat like an orange are, however, those best adapted for gaining a general idea of the structure of the group, and we shall accordingly commence with them.

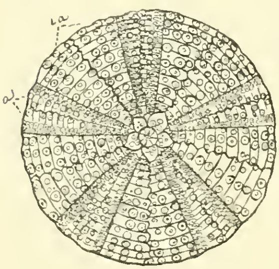


FIG. 1.—Upper Surface of the Test of the Common Sea-Urchin. *a*. Ambulacral areas; *i a*. intermediate areas.

If, then, we examine such a test, we shall find that it has an aperture at each of the two poles; while it is divided into a series of meridional areas, each composed of a number of separate oblong calcareous plates, fitting accurately with one another at their edges, where they are united by a thin membrane. The upper surface of such a test is shown in Fig. 1, from which it will be seen that the upper or apical pole, as it may be conveniently called, consists of five somewhat heart-shaped plates surrounding a small circular orifice which is closed with membrane in the living state. This central orifice is the *vent*, while the five plates forming a star surrounding it, which generally fall out in the dry state, constitute the *apical disc*. At the opposite or lower pole, we shall find a much larger aperture, which forms the creature's mouth; and we may observe that just inside this aperture of the test in the complete animal, there will be found a very complicated calcareous masticating apparatus known as *Aristotle's lantern*. Putting aside for the present the apical disc, we may devote somewhat fuller attention to the main body of the test, technically termed the *corona*. As we have said, this consists of a series of meridional areas composed of numerous small plates; and we shall find that these areas form ten alternating series, each of which consists of two meridional rows of the aforesaid plates. The line of division between the two rows in each area is well marked, although the divisions between any two areas are much less distinct. It will further be seen that, while in one series of areas (*i a*) the plates are much wider than in the other series (*a*), they are also somewhat deeper. Now, if we were to look from the inside of the test towards the light, we should find that the outer half of each plate in the narrower areas has several minute perforations; and it is through these minute perforations that, during life, the animal protrudes the curious tube-like feet, by the sucker-like action of which an Urchin is enabled to climb up the glass wall of an aquarium. As these narrower areas are connected with the function of progression, they are appropriately termed the *ambulacral areas*, and the larger intervening spaces are accordingly called the *intermediate areas*. It is almost superfluous to add that the whole test of an Urchin thus consists of five ambulacral and five intermediate areas, which between them comprise twenty separate rows of plates, each running continuously from one polar aperture to the other. During life each platei s separated from its neighbour by a thin membrane, and the test increases in size both by additions to the edge of each plate and also by the interpolation of fresh equatorial zones of plates between the upper edge of the corona and the apical disc. The spines of the Urchins are movably attached to the knobs with which the test is covered, and vary much in form and size, although the limits of this article do not admit of further reference to them.

Reverting to Fig. 1, we may also see that the ambulacral areas of the Common Urchin form a five-rayed star, on the test of which, in the position of the figure, three rays are turned away from the spectator and two towards him. Now this radiate arrangement at once forciby reminds us of a Star-Fish, and any person who has ever handled those creatures when alive will be aware that from their under surface they can protrude tube-like sucking feet, precisely similar to those we have referred to as existing in the Urchins. Both these points of resemblance are, indeed, indicative of an intimate relationship between Urchins and Star-Fish. And, as a matter of fact, the ambulacral areas of the one represent the five rays of the other; the intermediate areas of the Urchins being an addition to the structure of the Star-Fish. At first sight it looks, indeed, as if these animals were really symmetrically radiate, but we shall show later on that this is not the case, and that they are, in truth, bilaterally symmetrical like the higher animals, although this bilateral symmetry has been more or less thoroughly masked by the radiate arrangement of the parts.

Urchins and Star-Fishes are, however, not the only members of the group of Echinoderms; since this also comprises the beautiful Stone-Lilies or Encrinites, the joints of the stems of which form the well-known "St. Cuthbert's Beads," of the Whitby Lias, while the so-called Entrochal Marble, so often employed for chimney-pieces and other decorative architecture, is almost entirely composed of these stems. There are, moreover, certain entirely extinct types, such as the Cystoids and Blastoids, of which more anon.

Before proceeding to trace the modifications which the test of the Urchins undergoes in different members of the group, it may be observed that in all Urchins, whether recent or fossil, the number of meridional areas is invariably ten; while in every existing kind of Urchin, no matter what be its size or shape, the number of rows of plates composing such areas never departs from twenty. As soon, however, as we reach the strata lying below the chalk and gault, known as the lower greensand, which constitute the lower part of the Cretaceous system, we find an Urchin which departs somewhat in the last-named respect from the existing type. A side view of the test of this species is given in Fig. 2, from which it will be seen that while at the apical pole the number of meridional rows of plates is the normal twenty, as we approach the equator the number of meridional rows in each intermediate area is increased to four, which continue to the

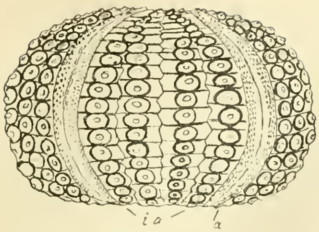


Fig. 2.—Side view of the test of a Cretaceous Sea-Urchin (*Tetracidaris*). Letters as in Fig. 1.

basal pole. Going still further back to the Trias, we find another genus of Urchins (*Tiarechinus*) with an increase in the number of rows of plates in the intermediate areas above the lower pole. Moreover, some of the Urchins of the still older Jurassic rocks differ from the ordinary type, in that the plates overlap one another instead of joining by their edges.

These departures from the normal form in some of the Secondary Urchins suggest that, if we were to go back to the Palæozoic epoch, we should find still more marked differences from living types. Such, indeed, is actually the case, and we find that all the Palæozoic Urchins differ from existing ones in the number of meridional rows of plates, while very frequently these plates overlap one another. In the specimen represented in Fig. 3 it will be seen that while the ambulacral areas are normal, the intermediate areas have now no less than five meridional rows of plates; while in yet another form (*Melonites*) the ambulacral as well as the intermediate rows are increased in number, the former varying from seven to eight, and the latter from eight to fourteen. With one exception, however, all the Palæozoic Urchins agree with the Common Urchin in having the vent situated at the apical, and the mouth at the basal pole, this mouth always having the "Aristotle's lantern."

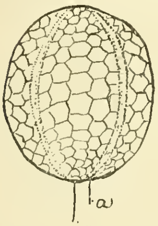


Fig. 3.—Side view of the test of a Palæozoic Sea-Urchin (*Palæoechinus*). Letters as in Fig. 1.

Now if we proceed still further back till we reach the lower part of the Palæozoic epoch, such as the Cambrian and Lower Silurian, we shall find a totally extinct group of Echinoderms known as Cystoids. The hard parts of these creatures consist of a nearly globular test, usually supported on a short stalk, and composed of a number of polygonal plates, having no definite meridional arrangement, but traversed by five, or fewer, irregular ambulacral grooves radiating from the mouth. And it will be obvious that, in their large number of meridional rows of plates, the Palæozoic Urchins present a much closer resemblance to these extinct Cystoids than is offered by their existing representatives. Indeed, if we believe in the derivation of one form of animal from another, it seems pretty evident that starting from the Cystoids—the oldest known Echinoderms—we can pass readily into the Palæozoic Urchins, from which we are conducted by the above-mentioned intermediate Secondary forms to species of the type of the Common Urchin of the present day. What particular advantage the modern Urchins have gained by the reduction of their meridional rows to twenty is, however, not very easy to determine; although this reduction has probably conduced to greater compactness and strength in the structure of their test, which may alone have been a sufficient improvement on the older types.

The transition from the Palæozoic to the modern forms does not, however, by any means exhaust the modifications which the Urchins have undergone with the march of time. Reverting once more to the Common Urchin (Fig. 1), it should be mentioned that this type, in which the test is radiately symmetrical and the vent and mouth are polar, constitutes the group of the so-called Regular Urchins. Although this type is still well represented, yet a large number of the Urchins of the Secondary, Tertiary, and recent periods have departed very considerably from this simple form, to assume a more or less decided heart-shape, with one or both apertures of the test becoming eccentric, and with a frequent tendency for the perforated portions of the ambulacral areas to become restricted to the central part of the upper surface, where they form a flower-like pattern (Fig. 4). Such types constitute the group of Irregular Urchins, which, on the doctrine of evolution, may be safely regarded as derived from the Regular group. Moreover, not satisfied with the assumption of these new shapes, the Irregular Urchins appear to have considered the "Aristotle's lantern," which had served their ancestors as a masticating organ for countless ages, only a useless encumbrance, and, accordingly, the more advanced "radicals" among them have totally discarded this piece of apparatus, and, indeed, appear to get on equally well without it.

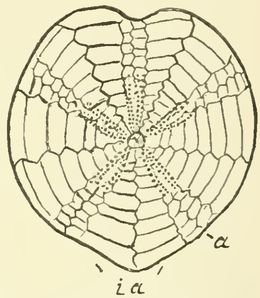


Fig. 4. — Upper surface of the test of a Cretaceous Heart Urchin (*Micraster*). Letters as in Fig. 1.

The forms connecting the more aberrant members of the Irregular with the Regular group of Urchins are both numerous and varied. Among them we may refer to the common little Helmet Urchin (*Echinoconus*) of our chalk. The test of this species is about an inch in height, and forms a tall cone, which is not quite radiately symmetrical. The mouth, indeed, retains its usual position at the basal pole, while the perforated areas extend from pole to pole. In place, however, of the vent being situated in the centre of the apical disc, it has been transferred to the margin of the lower surface, in the middle of one of the intermediate areas. It is thus placed opposite to an ambulacral area corresponding to the one directed upwards in Fig. 1; and we thus, for the first time, find a regular bilateral symmetry fully established. In the particular species to which we have referred (as in all the under-mentioned forms), the "Aristotle's lantern" has been lost, although it is retained in other members of the same group. One specimen of a Helmet Urchin has been discovered showing the rare abnormality of having but four ambulacral areas.

A further step is shown by the so-called Sugar Loaf Urchin (*Ananchytes*) of the English chalk, the tall silicified tests of which are so commonly found in the gravel derived from the denudation of the chalk. In this species, which is considerably larger and more ovoid than the Helmet Urchin, the elevated form of the test is still retained, but the contour of its under surface has become more decidedly heart-shaped. Moreover, the vent has become shifted completely on to the lower surface; while the mouth, although remaining (as is invariably the case) on the under surface, has travelled away from its original central position so as to be placed in the ambulacral area

corresponding to the one directed upwards in Fig. 1. Here, therefore, we have the bilateral symmetry still more distinctly marked. Another advance shown in this Urchin, is the circumstance that the perforated portions of the ambulacral areas do not extend on to the lower surface of the test, but stop short at the edge. Some members of the same family are still more peculiar in that the apical disc is greatly elongated from front to back, in consequence of which the five ambulacral areas do not all meet one another at the summit of the test; those corresponding to the three turned away from the spectator in Fig. 1 meeting near the middle of the test, while the remaining two are brought together in the opposite part of the test corresponding to the lower portion of Fig. 1.

A third common chalk species, the Heart-Urchin, or Fairy Heart of the quarrymen (*Micraster*), affords a good example of what may be regarded as the extreme modification of structure developed in the group. The upper surface of one of these Urchins is represented in Fig. 4, from which it will be seen that the contour is regularly heart-shaped, and the whole test much depressed. The perforated portions of the ambulacral areas are now restricted merely to the central region of the upper surface, one of these areas (directed upwards in the figure) forming a shallower groove, and being otherwise markedly different from all the others. In such an Urchin the bilateral symmetry is very strongly marked indeed, and, since the upper border of the figure represents the anterior, and the lower the posterior extremity of the animal, we may compare the three anterior ambulacral areas to the head and arms of a quadruped whose hind legs will be represented by the two posterior ambulacra. In regard to the position of the two orifices of the test in this species, the vent is situated on the flattened posterior surface, near its junction with the upper surface, while the mouth occupies a position nearly midway between the centre and the anterior border of the lower surface, at the commencement of the groove formed by the anterior ambulacral area. The mouth is peculiar in that it does not open directly on the surface, in the usual manner, but has a projecting lip by means of which its aperture assumes a forward direction. The common Purple Heart-Urchin (*Spatangus*) of our present seas is a larger representation of this group, presenting the same general type of structure.

We thus see how gradual is the passage from a species of the type of the Common Urchin to that of the Heart-Urchin, widely different as are these two from one another. We might, indeed, proceed further with our investigations, and show how certain of the Irregular Urchins have become so flattened as to assume the form of thin plates, which in some instances are deeply notched at their periphery. And we might also investigate the variation of form and size displayed by the spines of the different groups. Enough has, however, been written for our present object, which has been to show the amount of interest that attaches to the investigation of the lines of modification on which development has proceeded among the Sea-Urchins. This has shown how a regular progressive advance in one particular direction has taken place from the earlier to the later members of the group; and we thus have another excellent instance testifying in favour of the doctrine of evolution. This brief sketch may possibly give additional pleasure to a sea-side sojourn, by inducing some of our readers to direct their attention, first of all, to the recent Sea-Urchins, after which they will scarcely fail to extend their investigations to the fossil species so abundantly distributed through our rocks; and, we will venture to add, that if they do so their interest cannot fail to be aroused.

THE FACE OF THE SKY FOR DECEMBER.

By Herbert Sadler, F.R.A.S.

THE markings on the solar surface show no signs of diminution. The following are conveniently observable minima of some Algol-type variables (*cf.* "Face of the Sky" for November). U Cephei.—December 1st, 10h. 9m. p.m.; December 6th, 9h. 49m. p.m.; December 11th, 9h. 28m. p.m.; December 16th, 9h. 8m. p.m.; December 21st, 8h. 48m. p.m.; December 26th, 8h. 28m. p.m.; December 31st, 8h. 7m. p.m. Algol.—December 15th, 11h. 43m. p.m.; December 18th, 8h. 31m. p.m.; December 21st, 5h. 20m. p.m. A minimum of the variable star Mira (Omicron) Ceti will occur on the 29th of December. The magnitude at minimum varies from 8 to $9\frac{1}{2}$ magnitude, and the star is of a fiery red colour at that stage.

Mercury is an evening star, and would be well situated for observation during the first three weeks of the month but for its great southern declination. He sets on the 1st at 4h. 42m. p.m., or 49m. after the Sun, with an apparent diameter of $5\frac{1}{2}''$, and a southern declination of 25° 49′, $\frac{5}{10}$ of the disc being illuminated. On the 13th he sets at 5h. 8m. p.m., or 1h. 19m. after the Sun, with an apparent diameter of 7·0″, and a southern declination of 24° 36′, $\frac{43}{100}$ of the disc being illuminated. About this time he is at his brightest. On the 18th he sets at 5h. 10m. p.m., or 1h. 20m. after the Sun, with an apparent diameter of 8·0″, and a southern declination of 23° 20′, $\frac{38}{100}$ of the disc being illuminated. After this he rapidly approaches the Sun, coming into inferior conjunction with him on the 28th. He is at his greatest eastern elongation ($20\frac{1}{2}$°) on the 11th, and in conjunction with λ Sagittarii on the morning of the 7th, but the phenomenon will not be visible in Europe. While visible he describes a direct path in Sagittarius. Venus is also an evening star, but is almost as indifferently placed for the observer as Mercury is. She sets on the 1st at 4h. 56m. p.m., or 1h. 3m. after the Sun, with a southern declination of 24° 23′, and an apparent diameter of $10\frac{1}{2}''$, $\frac{95}{100}$ of her disc being illuminated, while her brightness is less than one quarter of what it was at the beginning of the year. On the 31st she sets at 6h. 4m. p.m., or 2h. 6m. after the Sun, with a southern declination of 20° 35′, and an apparent diameter of $11\frac{1}{4}''$, $\frac{9}{10}$ of the disc being illuminated. During the month she passes from Sagittarius into Capricornus, but without approaching any conspicuous star.

Both Mars and Uranus are, for the purposes of the amateur, invisible; and Saturn does not rise on the last day of the month till 11h. 9m. p.m. We therefore defer our ephemeris of him till next year. Jupiter is still favourably placed for observation as an evening star, but should be observed as soon as possible after sunset. He sets on the 1st at 11h. 33m. p.m. with a southern declination of 9° 12′, and an apparent equatorial diameter of $40\frac{1}{4}''$, the phasis on the preceding limb amounting to $40\frac{1}{4}''$. On the 31st he sets at 9h. 46m. p.m. with a southern declination of 7° 37′, and an apparent equatorial diameter of $36\frac{3}{4}''$. The following phenomena of the satellites occur while Jupiter is more than 8° above, and the Sun 8° below, the horizon. On the 1st an occultation disappearance of the first satellite at 6h. 12m. p.m., and an eclipse reappearance of the same satellite at 9h. 49m. 21s. p.m. On the 2nd a transit egress of the first satellite at 5h. 39m. p.m., and of its shadow at 7h. 0m. p.m. On the 4th an occultation disappearance of the second satellite at 7h. 7m. p.m., and an eclipse disappearance of the fourth satellite at 9h. 25m. 11s. On the 5th a transit egress of the third satellite at

6h. 21m. p.m., and a transit ingress of its shadow at 8h. 26m. p.m. On the 6th a transit ingress of the shadow of the second satellite at 5h. 2m. p.m.; a transit egress of the satellite itself at 5h. 10m. p.m.; and a transit egress of its shadow at 7h. 51m. p.m. On the 8th an occultation disappearance of the first satellite at 8h. 9m. p.m. On the 9th a transit ingress of the first satellite at 5h. 17m. p.m.; of its shadow at 6h. 38m. p.m.; a transit egress of the satellite at 7h. 36m. p.m., and of its shadow at 8h. 55m. p.m. This transit should be carefully watched, as the satellite may possibly appear to be double. On the 10th an eclipse reappearance of the first satellite at 6h. 13m. 53s. p.m. On the 11th an occultation disappearance of the second satellite at 9h. 46m. p.m. On the 12th a transit ingress of the third satellite at 6h. 59m. p.m., and of the fourth satellite at 7h. 20m. p.m. This will be a very interesting phenomenon. On the 13th a transit ingress of the second satellite at 4h. 57m. p.m.; of its shadow at 7h. 39m. p.m.; and a transit egress of the satellite itself 11m. later. On the 16th an eclipse reappearance of the third satellite at 5h. 36m. 44s. p.m.; a transit ingress of the first satellite at 7h. 14m. p.m.; of its shadow at 8h. 34m. p.m.; and a transit egress of the satellite itself at 9h. 33m. p.m. On the 17th an eclipse reappearance of the first satellite at 8h. 9m. 26s. p.m. On the 18th a transit egress of the shadow of the first satellite at 5h. 20m. p.m. On the 20th a transit ingress of the second satellite at 7h. 38m. p.m. On the 21st an eclipse reappearance of the fourth satellite at 6h. 41m. 48s. p.m. On the 22nd an eclipse reappearance of the second satellite at 7h. 12m. 51s. On the 23rd an eclipse disappearance of the third satellite at 6h. 37m. 2s. p.m., and a transit ingress of the first satellite at 9h. 13m. p.m. On the 24th an occultation disappearance of the first satellite at 6h. 34m. p.m. On the 25th a transit ingress of the shadow of the first satellite at 4h. 59m. p.m.; a transit egress of the satellite itself at 6h. 1m. p.m.; and of its shadow at 7h. 16m. p.m. On the 29th a transit egress of the fourth satellite at 6h. 42m. p.m. On the 30th an occultation disappearance of the third satellite at 5h. 31m. p.m. On the 31st an egress of the shadow of the second satellite at 5h. 0m. p.m., and an occultation disappearance of the first satellite at 8h. 33m. p.m. During the month Jupiter describes a direct path in Aquarius, but without approaching any naked eye star very closely.

Neptune is excellently situated for observation, rising as he does on the 1st at 3h. 38m. p.m., with a northern declination of 19° 58′, and an apparent diameter of 2·7″. On the 31st he rises at 1h. 50m. p.m., with a northern declination of 19° 51′. During the month he describes a short retrograde path to the north of ε Tauri. A map of the stars down to $10\frac{1}{2}$ magnitude near his path will be found in the *English Mechanic* for October 16th, 1891.

December is a fairly favourable month for shooting stars, the chief shower being that of the Geminids on December 9th–12th, the radiant point being in R.A. 7h. 0m., and north declination 32°, rising about 4h. 10m. p.m., and setting at 1h. 40m. a.m.

The Moon enters her first quarter at 5h. 13m. p.m. on the 8th; is full at 0h. 53m. a.m. on the 15th; enters her last quarter at 5h. $38\frac{1}{2}$m. on the 23rd; and is new at 3h. 20m. a.m. on the 31st. She is in perigee at 6·1h. p.m. on the 11th (distance from the earth, 228,540 miles); and is in apogee at 6·0h. p.m. on the 23rd (distance from the earth, 241,300 miles). The greatest eastern librations are at 1h. 7m. p.m. on the 3rd, and at 1h. 30m. a.m. on the 30th; and the greatest western at 1h. 18m. p.m. on the 17th.

Chess Column.

By C. D. Locock, B.A.Oxon.

All communications for this column should be addressed to the "Chess Editor, *Knowledge Office*," and posted before the 10th of each month.

Solution of Problem No. 5 (*by D. R.*) 1. Kt to K4. If 1. . . . K×Kt; 2. Kt to B7, etc. Or if 1. . . . K to K3; 2. Kt (from K8) to Q6, etc.

Correct Solutions from :—Alpha, Betula, H. S. Brandreth, Giu. Pianissimo, C. T. Blanshard, G. F., W. E. B., W. T. Hurley, J. G. Ellis, R. T. M., F. R., R. W. Compton, C. S., White Knight, M. B. (Jesmond), T., A. Rutherford, R. W. Houghton, and J. Taylor.—(19 correct, 1 incorrect.)

J. E. Smith.—See above for correct solution.

C. T. B.—You sent two replies, both correct (Nov. 3rd and 7th).

W. T. Hurley.—Duals do not count, except of course in the key-move. See rules in June number.

T.—Well-known problems would be inadmissible in a solution tourney. The game you refer to has been ably annotated elsewhere.

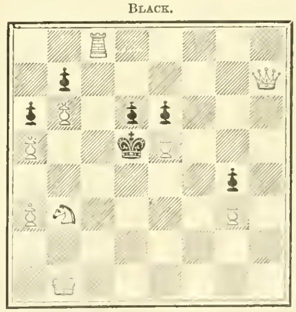
C. S.—The problem seems all right now. Shall be glad to insert early in the next tourney.

Black Combe.—Your letter was delayed. Will reply next month.

PROBLEM (No. 6).

By C. D. L.

Black.



White.

White to play, and mate in three moves.

Leading Solvers' Scores.

Alpha	30	A. Rutherford	30
W. E. B.	30	T.	30
W. T. Hurley	30	J. Taylor	30
Giu. Pianissimo	30	Betula	26
F. R.	30	K.	22
R. W. Houghton	30	T. A. Earl	22
G. F.	30	J. G. Ellis	22
C. S.	30	White Knight	22
M. B. (Jesmond)	30	H. S. Brandreth	19
C. T. Blanshard	30	R. W. Compton	16
R. T. M.	30		

CHESS INTELLIGENCE.

The score in the recent Divan Tourney was as follows:—Bird, 6½; Tinsley, 5½; Müller, 5; Loman and Jasnagrodsky, 4½; Mortimer, Fenton, and Rolland, 4; Van Vliet and Gossip, 3½. The scoring was singularly even, the result of a large number of drawn games.

The Rev. A. B. Skipworth and Mr. J. H. Blake, who tied for first prize at the Oxford meeting of the Counties' Chess Association, played off their tie at the British Chess Club last month. After a hard struggle Mr. Blake proved the winner by two games to one, one game being drawn. Mr. Skipworth failed to make the most of his opportunities in more than one game.

The Championship Tournament of the City of London Club, and a Handicap at the British Chess Club, are now in progress. Mr. Loman is a notable absentee in the former contest. In the "British" Handicap Mr. Hoffer is in Class Ia by himself, giving the rather heavy odds of pawn and move to Class 1.

Messrs. Steinitz and Tchigorin are announced to play a return match at Havana, at the end of this month, the match to go to the winner of the first ten games, draws not counting. The length of the match is all in Mr. Steinitz's favour.

The following game was played at the Oxford meeting of the Counties' Chess Association last August.

[Centre Gambit.]

White (Dr. Hunt, North London).	Black (J. H. Blake, Southampton).
1. P to K4	1. P to K4
2. P to Q4	2. P × P
3. Q × P	3. Kt to QB3
4. Q to K3	4. Kt to B3 (*a*)
5. B to K2 (*b*)	5. P to Q3 (*c*)
6. B to Q2	6. B to K2 (*d*)
7. QKt to B3	7. Castles
8. Castles	8. R to Ksq (*e*)
9. Q to Kt3	9. B to Bsq
10. B to KKt5 (*f*)	10. B to K2
11. P to B4 (*g*)	11. Kt to Q2
12. Kt to B3	12. B × B
13. Kt × B	13. Kt to Bsq (*h*)
14. P to K5	14. B to K3
15. KKt to K4	15. K to Rsq
16. P × P	16. P to B4
17. P × P	17. Q × P
18. Kt to B5	18. Kt to Kt5
19. Kt × B	19. Kt × Kt
20. B to Kt5 (*i*)	20. Kt × KBP
21. R to Q7 (*j*)	21. Kt to K7ch
22. B × Kt	22. Q × R
23. B to B4 (*k*)	23. Q to Q5
24. B to Kt3	24. R to K6
25. Q to B7 (*l*)	25. R to Qsq
26. R to Qsq	26. R to K8
27. Q × Rch	27. Q × Q, and wins

Notes.

(*a*) Usually played now; the old defence by 4. . . . B to Kt5ch; 5. P to B3, B to R4; 6. Q to Kt3, Q to B3; 7. P to B4 not being very satisfactory for Black. Instead, however, of 6. . . . Q to B3, he may play 6. . . . Kt to B3, for White dare not play 7. Q × KtP, R to KKtsq; 8. Q to R6, Q to K2! followed by . . . R to Kt3.

(*b*) This, or B to Q2, is probably the best move. After 5. P to K5, Kt to KKt5; (or 5. . . . Kt to Q4; 6. Q to K4, Kt to Kt3; 7. Kt to KB3 (or P to QR4?), Q to K2, even game); 6. Q to K2! (not 6. Q to K4, P to Q4; 7. P × P *en passant*, B to K3; 8. P × P, Q to Q8ch!); 6. . . . P to Q3; 7. P to KR3, KKt × KP; 8. P to KB4, Kt to Q5; 9. Q to K4. Q to R5ch; 10. K to Qsq. Black saves the piece by Kt to K3! with a winning game.

(*c*) If 5. . . . B to K2; 6. P to K5 with the better position. An interesting game might result from 5. . . . B to Kt5ch; 6. P to B3, B to R4; 7. P to K5, B to Kt3; 8. Q to Kt5 (or 8. Q to B4, Kt to Q4; 9. Q to Kt3); 8. . . . B × Pch; 9. K to Bsq, Kt to K5; 10. Q × P, R to Bsq; 11. B to R6, and should win perhaps, for if 11. . . . B to B4; 12. P to QKt4!

(*d*) Or 6. . . . B to K3; 7. QKt to B3, P to Q4; 8. P × P, Kt × P, with a good game.

(*e*) White has taken for his model a recent correspondence game between Glasgow (White) and North London (Black). Black at this point continued 8. . . . P to Q4; 9. P × P, Kt × P; 10. Q to B3. The game was ultimately won by White. The text move is better. 8. . . Kt to KKt5 is met by 9. Q to B4 (best), P to KKt4?; 10, Q to Kt3.

(*f*) Defending the Pawn and threatening Kt to Q5.

(*g*) A weak move on principle. The Pawn cannot advance and may desire in vain to retreat. Kt to R3 seems safe enough, for if . . . B × Kt; 12. P × B with the open Kt's file. 11. B to Kt5 would obviously lose a piece by 11. . . . Kt to KR4.

(*h*) P to KR3 was now necessary, though White might play Kt × P, and B to R5ch.

(*i*) Here P to QR3 should have been played, followed by Kt to Q5.

(*j*) An oversight. P to QR3 or R to Q2 was still available.

(*k*) If 23. B to Kt5, Kt × RPch; or if 23. P to QR3, Kt to R7ch.

(*l*) If 24. R to Qsq, Q to K4. At his next move 25. Kt to Ktsq would be answered by R × B! The ending was very well played by Black.

Contents of No. 73.

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